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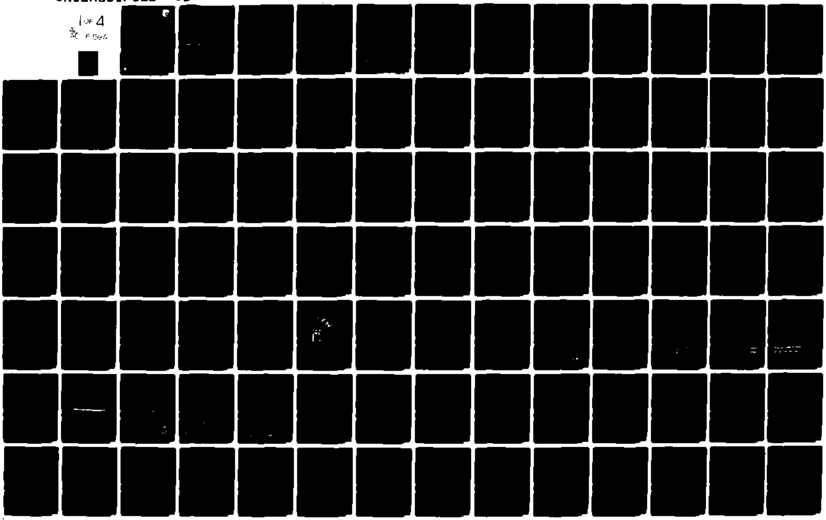

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STRUCTURAL FLIGHT LOADS SIMULATION CAPABILITY

VOLUME II - STRUCTURAL ANALYSIS COMPUTER PROGRAM USER'S MANUAL

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November 1980

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A complete system for the modeling, analysis and post-analysis of wing structures utilizing finite elements in simulated flight loads testing has been developed. The preprocessor incorporated the MAGNA element types 3, 4 and 5 (2-D membrane, truss and thin shells) into three predefined wing class models and allows for the conversion of existing wing models to be analyzed by MAGNA. MAGNA is a very powerful and flexible

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Finite Element Analysis
Finite Element Modeling
WINGEN
CONTOUR
PLOTBOB

20. (concluded)

material and geometrical nonlinear analysis program capable of solving a wide variety of finite element problems. Two postprocessors are coupled to the modeling and analysis of the wing structures to provide model geometry, stress or strain contour or relief displacement plots of the model and analysis results.

FOREWORD

This report describes the use of the computer programs developed by the University of Dayton Research Institute (UDRI) under Air Force Contract F33615-76-C-3135, "Structural Flight Loads Simulation Capability." This report is Volume II of a two volume final report Structural Flight Loads Simulation Capability. Volume I (Reference 3) is the Final Report. Volume II, described in this report, is the User's Manual for the various computer programs developed to fulfill the contract objectives. The effort was conducted for the Flight Dynamics Laboratory under the administration and technical direction of the following Air Force Project Engineers: Mr. William Hackenberger, Mr. Thomas Sabick, Mr. Charles Anderson, Capt. Paul Layte (Canadian Air Force), and Lt. Scott Dennis (AFWAL/FIESE).

Administrative project supervision at the UDRI was provided by Mr. Dale H. Whitford (Supervisor, Aerospace Mechanics Division), and technical supervision was provided by Dr. Fred K. Bogner (Group Leader, Analytical Mechanics Group). The following persons made technical contributions to the project: Dr. Robert A. Brockman, Mr. Jacques G. Gebara and Mr. Carl S. King.

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SECTION 1
INTRODUCTION

This report is a user's guide for the utilization of several interdependent computer programs which are designed to provide the survivability/vulnerability engineer with a tool for the utilization of finite element models (FEM's) in the simulation of structural flight loading of wings and wing components. This Structural Analysis Computer Program User's Manual, in conjunction with References 1 and 3, is designed to completely describe the utilization and interaction of four computer programs for predicting the static response of undamaged and ballistically damaged wing-like structures. The objectives of utilizing a simplified structural analysis tool are detailed in Reference 3 but may be summarized as follows:

(a) to provide a check on experimentally obtained data,

(b) to compute the internal stresses in an undamaged structure,

(c) to predict the stress redistribution in ballistically damaged structures, and

(d) to estimate the threshold and residual strength of ballistically damaged aircraft wing and empennage components.

These computer programs employ the finite element modeling (FEM) technique to discretize a wing structure into its various components in a fashion that provides an accurate mathematical representation of the wing. This model is then subjected to simulated experimental loading to determine the information desired in items a-d above.

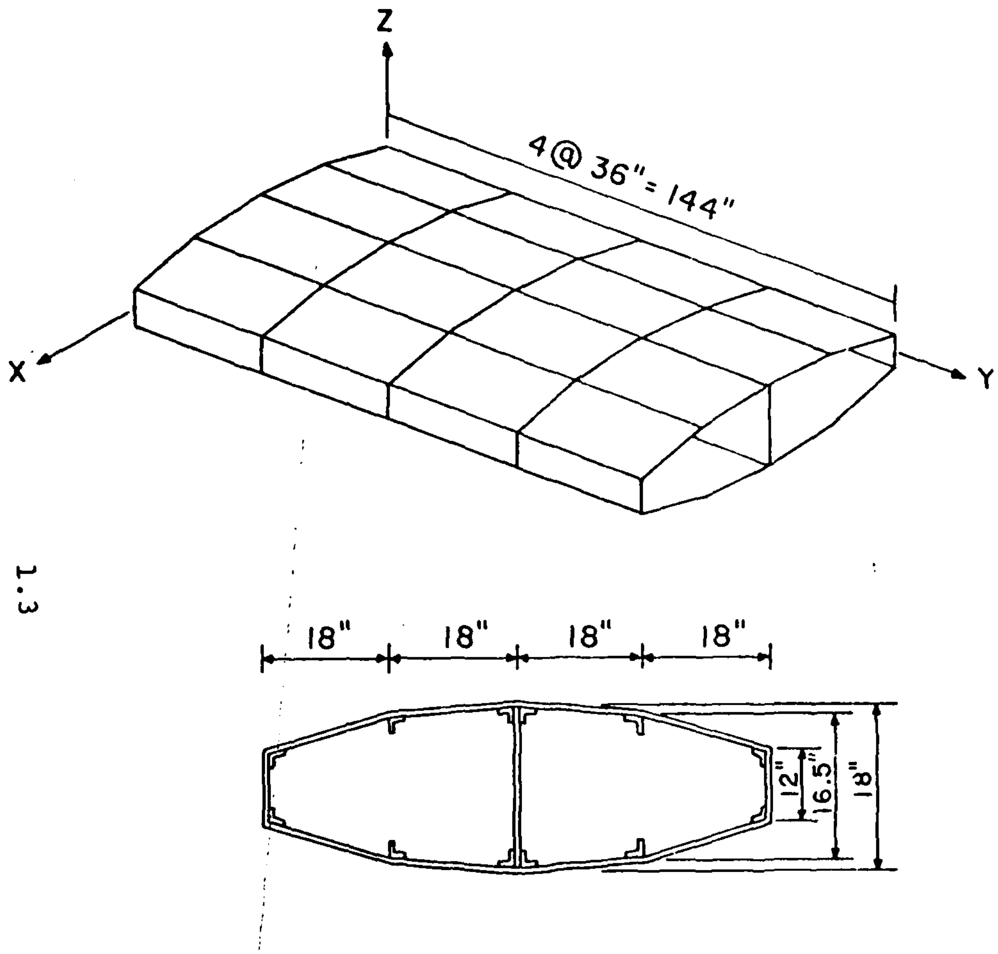
This section will provide a brief introduction to finite element modeling (FEM) and will then discuss briefly each of the component programs in the FEM (finite element model) approach to simulated flight loading. The remainder of this report addresses each of the components of FEM in turn: preprocessing

(WINGEN in Section 2); structural analysis (MAGNA in Section 3); and postprocessing (PLOTBOB and CONTOUR in Section 4). Included at the end of this report are several appendices illustrating procedures for executing the programs covered in this report. A glossary of terms is also provided with cross-referencing to help the user with terminology.

1.1 FINITE ELEMENT MODELING

The finite element method is a systematic process of reducing a structure, such as the one illustrated in Figure 1.1.1, into a set of interrelated nodes and elements. A node is a three coordinate point in space. A series of nodes are connected together to form mathematical (structural) components or finite elements. These components are then assembled to construct the FEM (finite element model). Figure 1.1.2 illustrates the assignment of nodes to the model illustrated in Figure 1.1.1. In this case a node has been defined for each alteration of the wing planform or for the intersection of spars, ribs, stringers or skins. Figure 1.1.3 illustrates the finite element components of the same wing model after the nodes of Figure 1.1.2 have been connected appropriately.

The 2-D elements (plate elements) numbered 1-16 of Figure 1.1.3 form the upper skin while the 1-D elements (bar elements) numbered 129-136 are stringers. The 2-D plate elements 33-52 comprise the five ribs defined for this model with the rib caps (1-D bar elements) being numbered 65-104. The spars are represented as 2-D plate elements numbered 53-64 with the spar caps (1-D bar elements) numbered 105-128. Finally, the lower skin is comprised of 2-D plate elements numbered 17-32 with stringers (1-D bar elements) numbered 137-144. Vertical posts are defined to provide the model with structural integrity and to prevent collapsing under analytical conditions. These are numbered 145-159. These 159 elements



STRUCTURAL COMPONENTS

SPARS (3) - WEB .2" THICK
RIBS (5) - WEB .08" THICK
SPAR CAPS - 2 × 2 × 3/16 ANGLE
RIB EDGES - 1 × 1 × 1/8 ANGLE
STIFFENERS (4) - 1-1/2 x 1-1/2 x 3/16 ANGLE
UPPER SKIN - .2 THICK
LOWER SKIN - .25" THICK

MATERIAL

ALUMINUM

Figure 1.1.1. A section of a full wing used for testing purposes. All the wing dimensions needed for creating a finite element model are given for this structure.

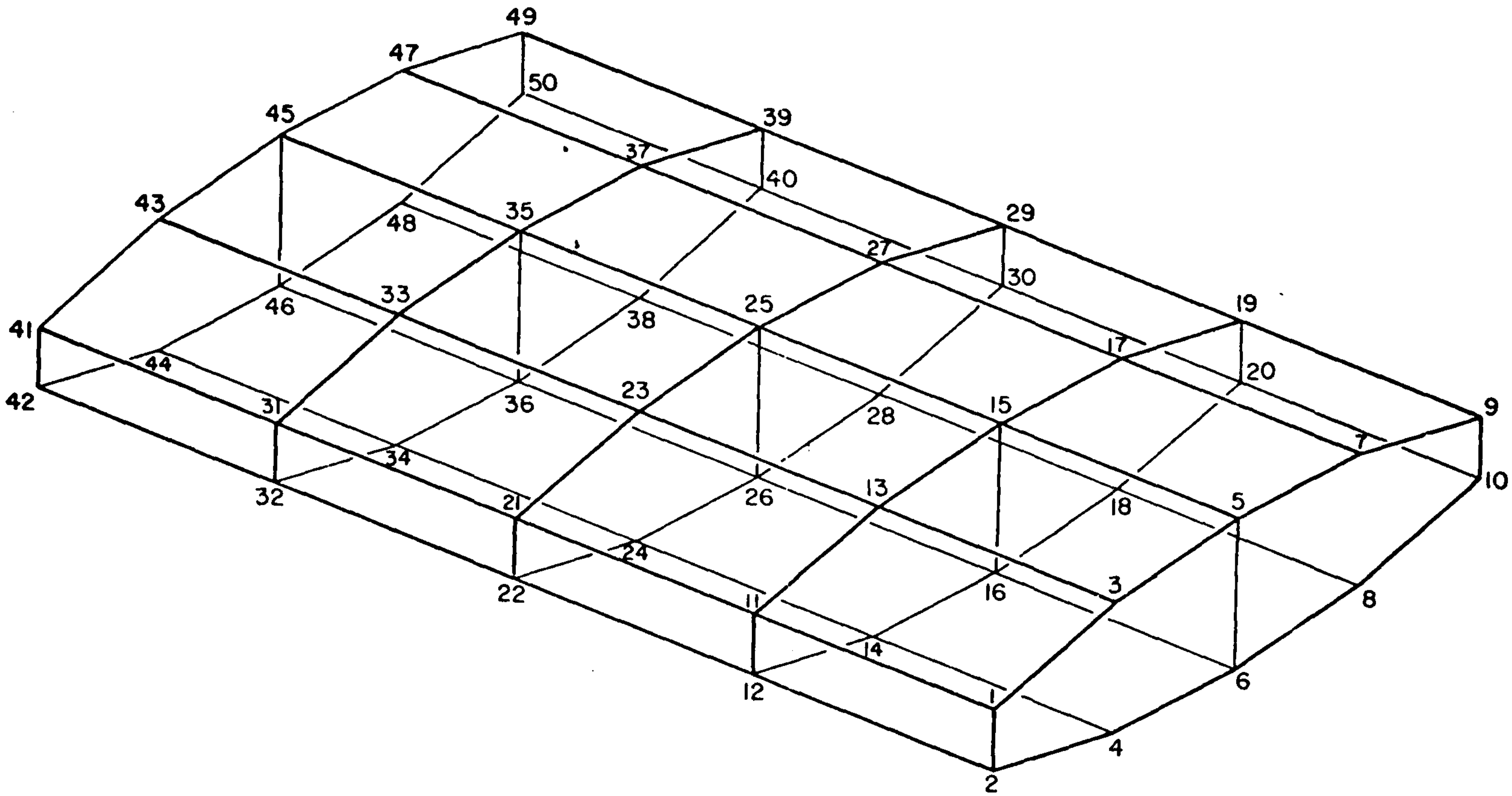


Figure 1.1.2. Coarse Finite Element Model with Node Numbers Assigned at all Critical Points.

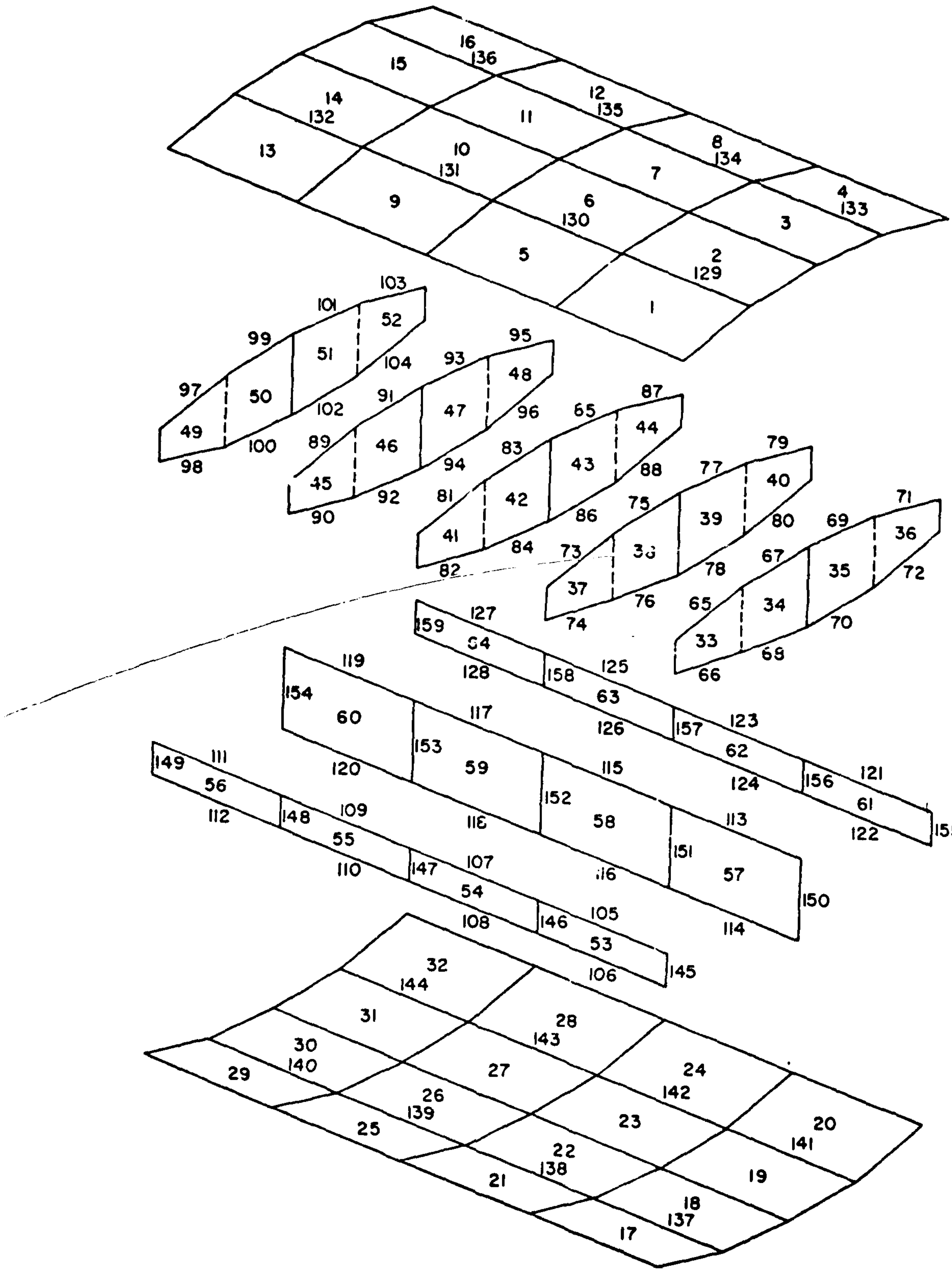


Figure 1.1.3. Coarse Finite Element Model with Elements Labeled. See Text for a Detailed Explanation.

combine to completely define a finite element model suitable for simulated loading analysis by an appropriate finite element model computer analysis program.

The process of developing an accurate model capable of efficient analysis is one that takes experience and intuition to be done properly. Due to the requirements of accuracy and detail necessary for the construction of a valid FEM model, computer programs have been developed recently that alleviate the user from the tedium of model definition in cases where the model falls into a well-defined series of geometric shapes. The wing structure for which this report is directed does fall into such a well-defined class of geometric structures and is, therefore, readily capable of having models generated by computer programs with the engineer required to define only basic node points and the geometry of the wing desired. A computer program can take this basic geometry data and generate all the nodes, elements, model constraints and loading values required. This file, containing all the model information, can be analyzed with the appropriate computer program. The output file from the analysis program must be examined, generally with a post-analysis program to extract information which is desired and present it in a form, such as graphs, which is readily comprehendable. Figure 1.1.4 illustrates the process of model definition from the engineer's conceptualization through the analysis process. Figure 1.1.5, discussed below, more fully illustrates the process of computer utilization in FEM development, analysis and postanalysis. The various items shown in Figure 1.1.5 are discussed briefly here to aid the reader in forming a clearer general understanding of the structural analysis tool; more detailed discussions on these areas are contained in subsequent sections and chapters of this report.

(a) Input Data -- This item represents the data which the survivability/vulnerability engineer must supply to the preprocessor program in order to define completely the physical structure to be simulated analytically.

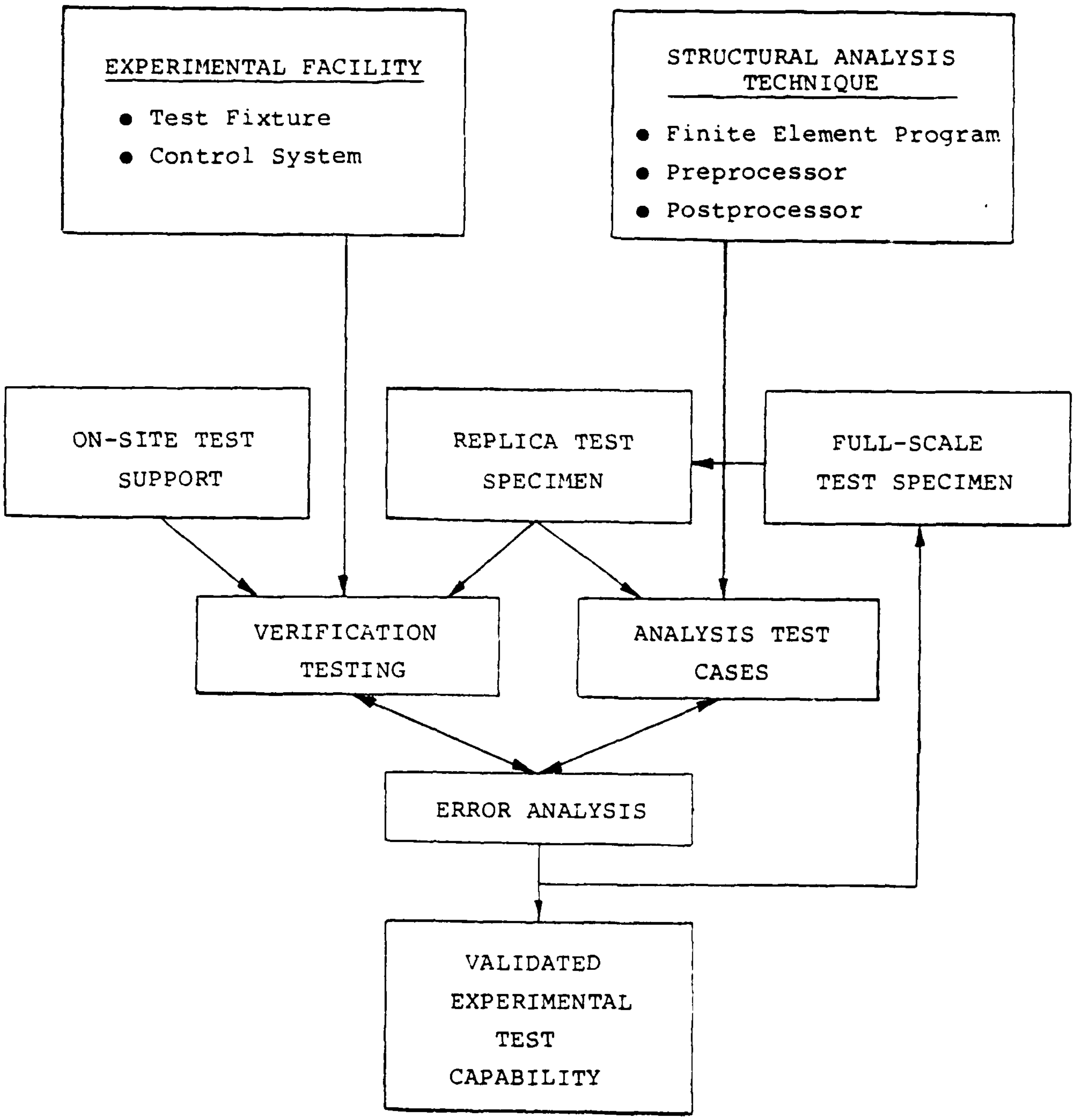


Figure 1.1.4a. Relationship of structural analysis technique with experimental technique.

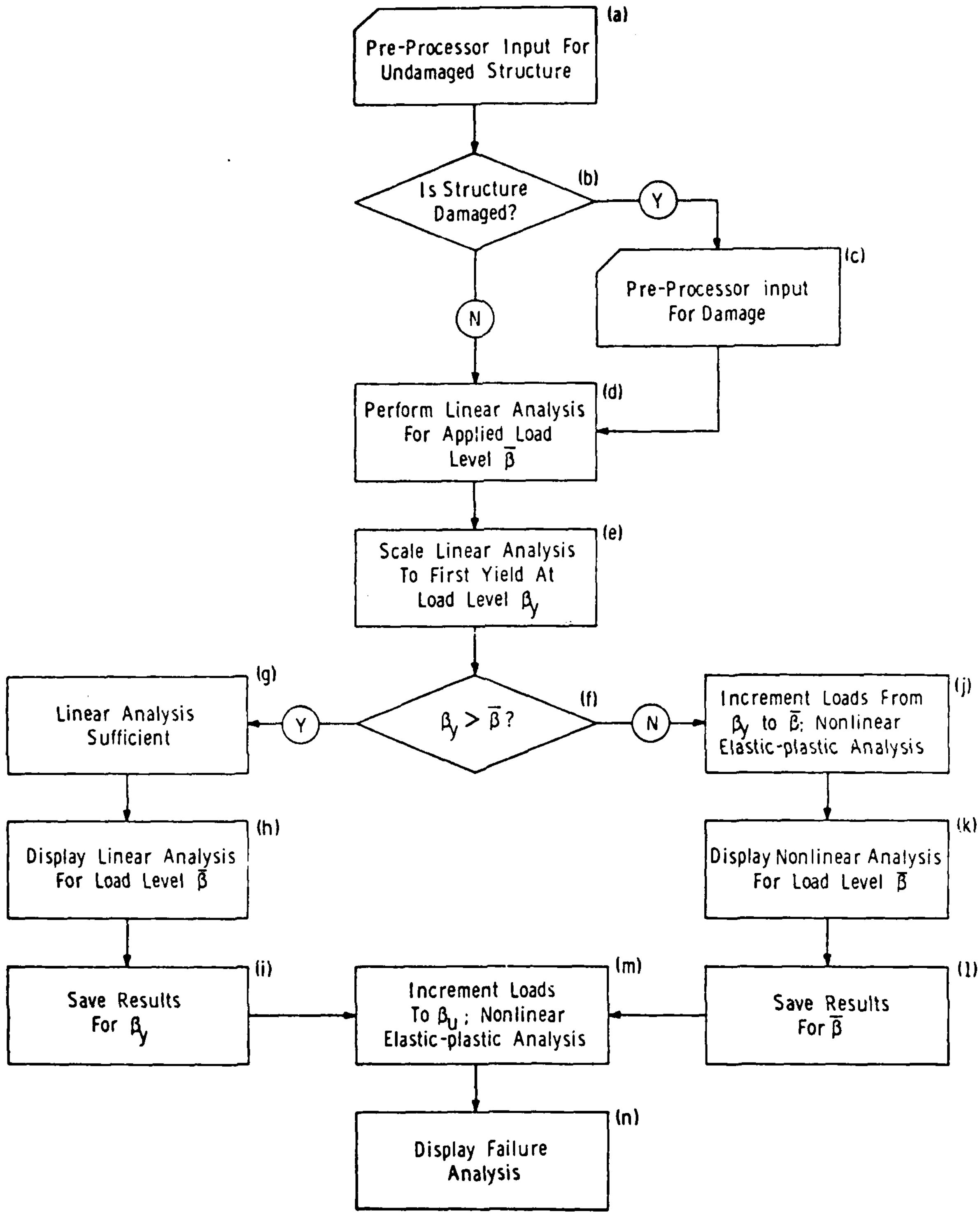


Figure 1.1.4b. Application of the Structural Analysis Technique.

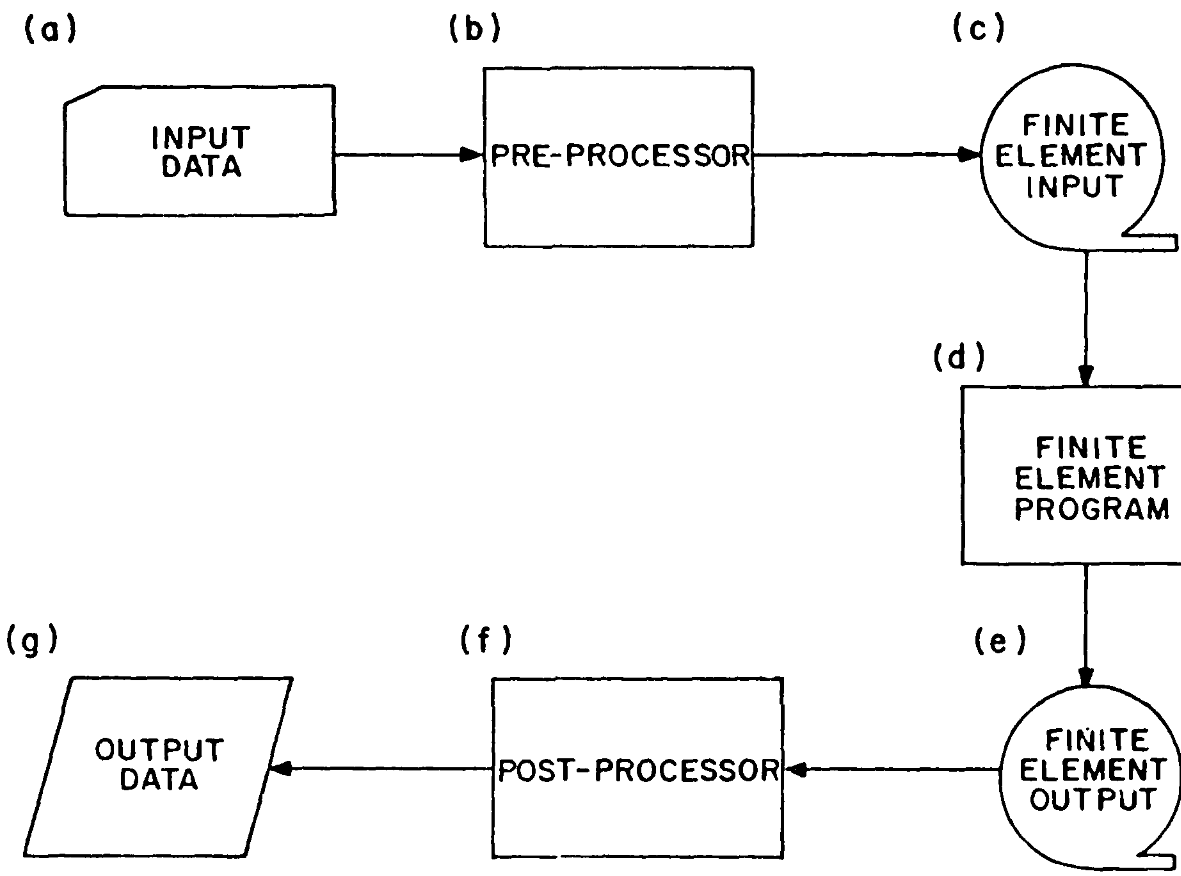


Figure 1.1.5. Finite Element Model Structural Analysis Technique.

(b) Preprocessor -- Assuming that the problem to be considered falls into one of a number of defined classes of problems, the primary functions of the preprocessor are to accept input data in an abbreviated format and to generate an expanded set of data which is accepted by the finite element program. Another function of the preprocessor is to display information concerning the generated finite element model to the survivability/vulnerability engineer in the form of printed output and undeformed geometry plots.

(c) Finite Element Program Data -- This item denotes the data which is generated and stored on auxiliary storage by the preprocessor and is accepted by the finite element program.

(d) Finite Element Program -- The finite element program is the backbone of the structural analysis technique. This program takes the finite element program data (load deck) and performs analysis simulating experimental conditions.

(e) Finite Element Program Output -- This item refers to the output which is printed by the finite element program. For the current program, this information is directed to auxiliary storage in the form of a WINGMPOST file for use by the postprocessing programs in addition to a printed tab of the data generated.

(f) Postprocessor -- The primary function of the postprocessor is to edit the output from the finite element program to eliminate any information which is not pertinent to the survivability/vulnerability engineer.

(g) Output Data -- This item represents the edited output data from the postprocessor. The output data available to the survivability/vulnerability engineer is generated in the form of plotted displacement and stress/strain results, deformed geometry plots and other graphs to illustrate the results of the analysis for quick and accurate interpretation.

The reader can see that the pre- and postprocessors essentially "straddle" the finite element program in such a manner that the composite analysis tool is convenient for the survivability/vulnerability engineer to use effectively.

The reader may feel that these programs and their interaction are very complex and provide very little effective results. However, once familiar with the processes involved and the mechanics explained in this report to model and analyze wing specimens, the user will find that considerable savings in time, effort, and money will be realized apart from the savings in materials once these analytical procedures are able to fully supplement regular structural testing.

1.2 PREPROCESSOR PROGRAM WINGEN

The nature of finite element modeling is such that much of the tedious work of generating a model may be performed very effectively by a computer. The preprocessor program WINGEN was designed specifically to alleviate the tedium of finite element modeling by providing for the generation of nodes and element connectivities for several classes of wing structures. The program will accept as input an abbreviated data file containing the basic defining parameters for the class of wing the user wishes to develop and will generate all the nodes and finite elements necessary to fully define the model. Since the abbreviated data file is generally no more than three or four dozen data cards and the output file generated can contain, at the least several hundred and very easily several thousand cards, the savings in time and energy is immediatley apparent, especially when alterations to damage specifications and loading conditions are made to the model. WINGEN has been developed to accommodate a batch format (card-image) data deck or can be used in a fully interactive mode. The same input information is required for either case and the output will be identical. If the user selects to utilize the interactive input method (no cards required) the program will create a model definition data deck for future use with the program to prevent the user from having to interactively input the basic model data more than once. Alterations and damages to the model or new loads may be specified in the batch format (model definition) data deck and the finite element data deck can be regenerated with these changes very quickly. Figure 1.2.1 illustrates how WINGEN operates with the various files and user interaction.

The flow of information diagram (Figure 1.2.1) for WINGEN illustrates the various input and output features of the program. Two input options are available:

(a) Card Deck input for batch mode execution. This option requires the user to place the model data on cards in the card deck or to attach a permanent computer resident disk file as a local file, TAPE4, which contains the model definition data detailed in Section 2.8.

(b) Interactive input allows the user to select fully interactive input where all model definition data is entered directly through a terminal (causing a USRDATAFILE to be created) or semi-interactive input where all model definition data is placed on a local file (TAPE4) for the program to use.

Several output options are available from WINGEN:

(a) A Batch mode output listing is generated if the card deck input option is selected.

(b) Model Geometry Plots are generated on an interactive graphics device, if requested.

(c) A Model Definition Data file is created and made a permanent disk file with the name USRDATAFILE if the user selects the fully interactive input option.

(d) A Model Load Deck file which is used to initiate an analysis of the FEM by MAGNA is generated if requested by the user. This file, TAPE11, must be catalogued by the user if a permanent disk file is desired.

WINGEN has been designed primarily to accommodate a user who wishes to execute the program interactively to generate a USRDATAFILE. Any modifications made to the Model Definition Data stored on the USRDATAFILE can be made and the USRDATAFILE attached as a local file (TAPE4) to be used for a semi-interactive execution of WINGEN. This means the user should not need to utilize the full interactive execution option more than once for each model. Section 2 discusses WINGEN in detail.

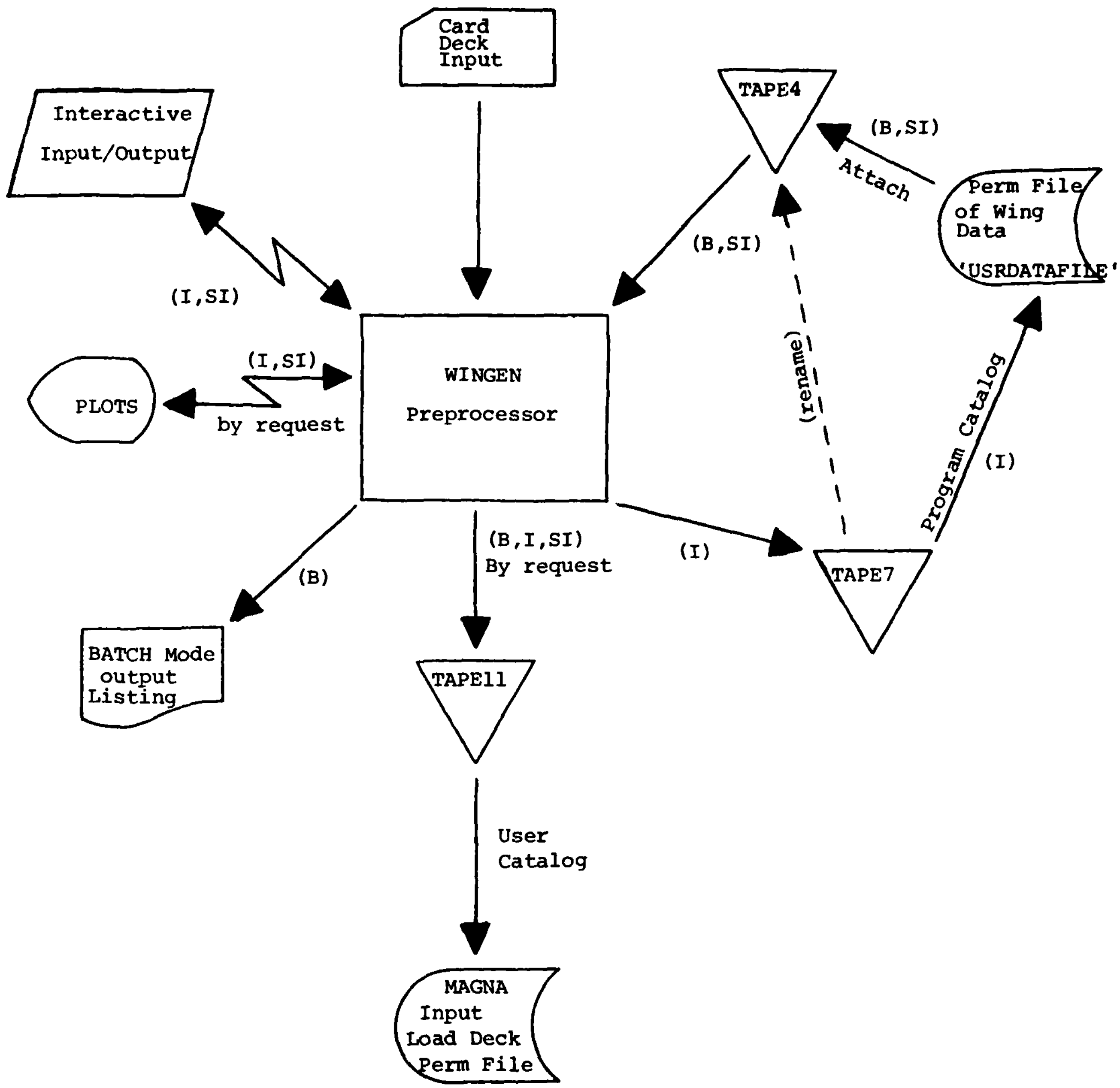


Figure 1.2.1. WINGEN operating environment. I = interactive mode; SI = semi-interactive mode; B = batch mode. These operating modes are explained in Chapter 2.

1.3 ANALYSIS PROGRAM MAGNA

Once a finite element model is defined it may be analyzed utilizing a finite element analysis program. MAGNA is a special purpose computer program developed specifically for the analysis of large displacements of finite element structures with up to several thousand degrees of freedom. It can handle material nonlinearities as well as geometric nonlinearities. WINGEN provides the user with all the necessary parameters to invoke the appropriate analysis types when the finite element model load deck is created. Since MAGNA has a wide variety of applications this allows the user to utilize MAGNA without the initial delay while becoming highly familiar with it. MAGNA will perform the analysis of the model utilizing the data file supplied by WINGEN. This will result in the production of an output or -MPOST file (WINGMPOST) which can be utilized by the postprocessing programs PLOTBOB and CONTOUR. Figure 1.3.1 illustrates the MAGNA operating environment.

This flow of information figure illustrates how the Load Deck created by WINGEN as TAPE11 can be used as input to execute a MAGNA analysis. TAPE11 can be either saved as a permanent disk file and accessed via card input or through interactive terminals or it can be punched as a card deck and submitted through card reader to initiate a MAGNA analysis. Since MAGNA must execute as a Batch job there can be no user interaction with the analysis. There is capability for two output files from MAGNA. An execution listing of the analysis containing results in a readable format is always generated. In addition the user will find a permanent disk file with the name WINGMPOST containing the same information as is contained on the output listing but in a condensed format for use by the postprocessing programs CONTOUR and PLOTBOB (see Section 4). Reference 1 contains complete information on MAGNA and how to use it. Section 3 provides an overview of MAGNA features and its interaction with the pre- and post-processors as well as a sample output listing.

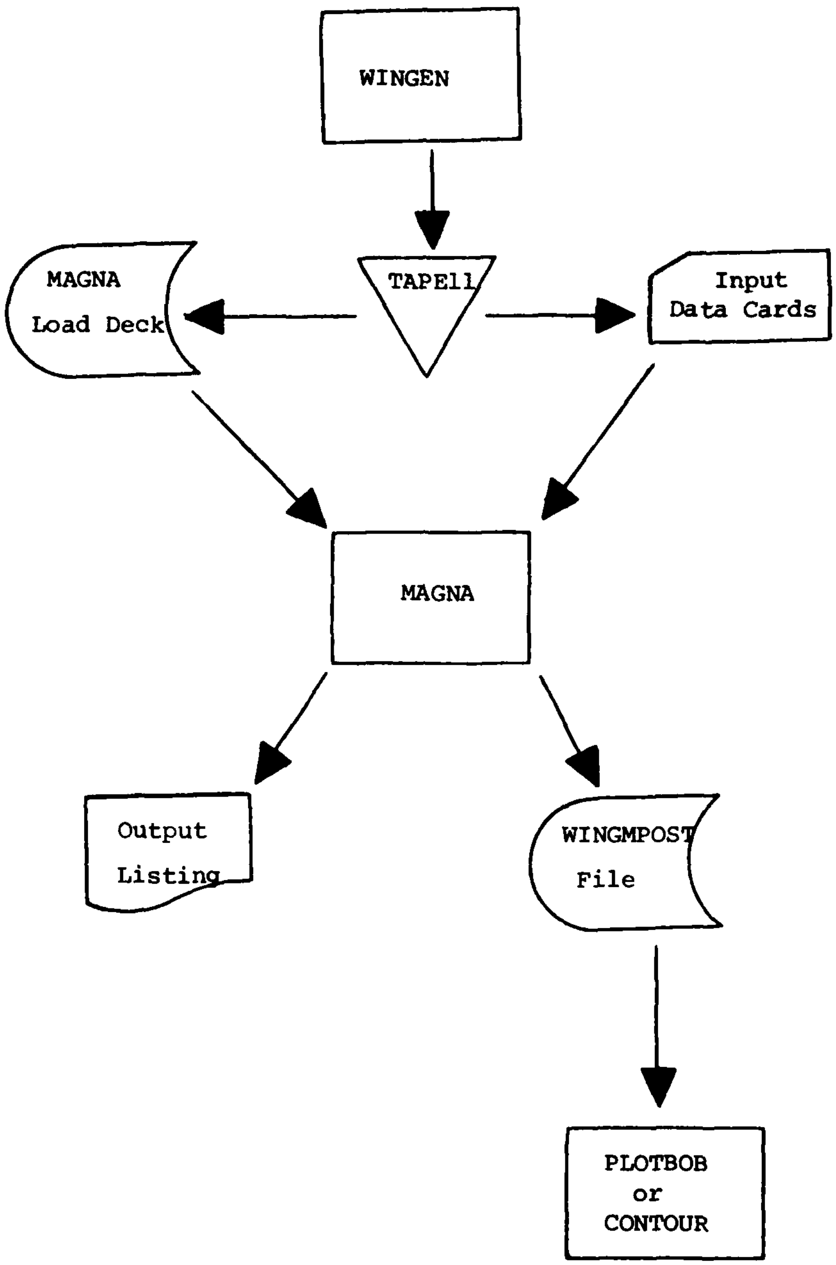


Figure 1.3.1. MAGNA operating environment. MAGNA can only be executed in a batch mode. Refer to Chapter 3 for further information.

1.4 POSTPROCESSOR PROGRAMS CONTOUR AND PLOTBOB

Postprocessing becomes an important tool in finite element modeling and analysis due to the large volumes of output necessarily generated. Postprocessing capability described in this report relates primarily to graphical representation of MAGNA analysis results. The results are displayed as either deformed structure plots or as contour plots with stress or strain values illustrated by contour lines drawn on the model. This type of data presentation is very effective in allowing the user to immediately comprehend the distribution of forces throughout a structure and thereby help to more rapidly isolate where and when the structure might fail. Since graphical presentation of data is considerably easier to understand than large computer output tabs and because much data presented in output tabs is useless unless the user can know precisely how the data relates to the model in question, plotted results answer a critical need by bridging the theoretical and the conceptual ideas of finite element modeling.

The interaction of WINGEN, MAGNA, PLOTBOB, CONTOUR, and the user is illustrated in Figure 1.4.1. These four programs provide a complete set of tools for the model development, analysis, and post-analysis data reduction required in finite element model analysis.

The flow of information illustrated in Figure 1.4.1 is a combining of the information from Figure 1.2.1 and 1.3.1 with the addition of the postprocessing program.s It becomes apparent from this figure that PLOTBOB has the capability of making geometry plots illustrating the structure to be analyzed from the same Load Deck data file that initiates a MAGNA analysis. PLOTBOB will also generate geometry plots of the WINGMPOST file that is produced by a MAGNA analysis. CONTOUR will generate contour, displacement and geometry plots of the WINGMPOST data file only. Section 4 details use of these two programs. In addition Reference 4 contains some additional information about these two postprocessing programs. In Reference 4 CONTOUR has been renamed to CPLOT and PLOTBOB has the new name GPLOT.

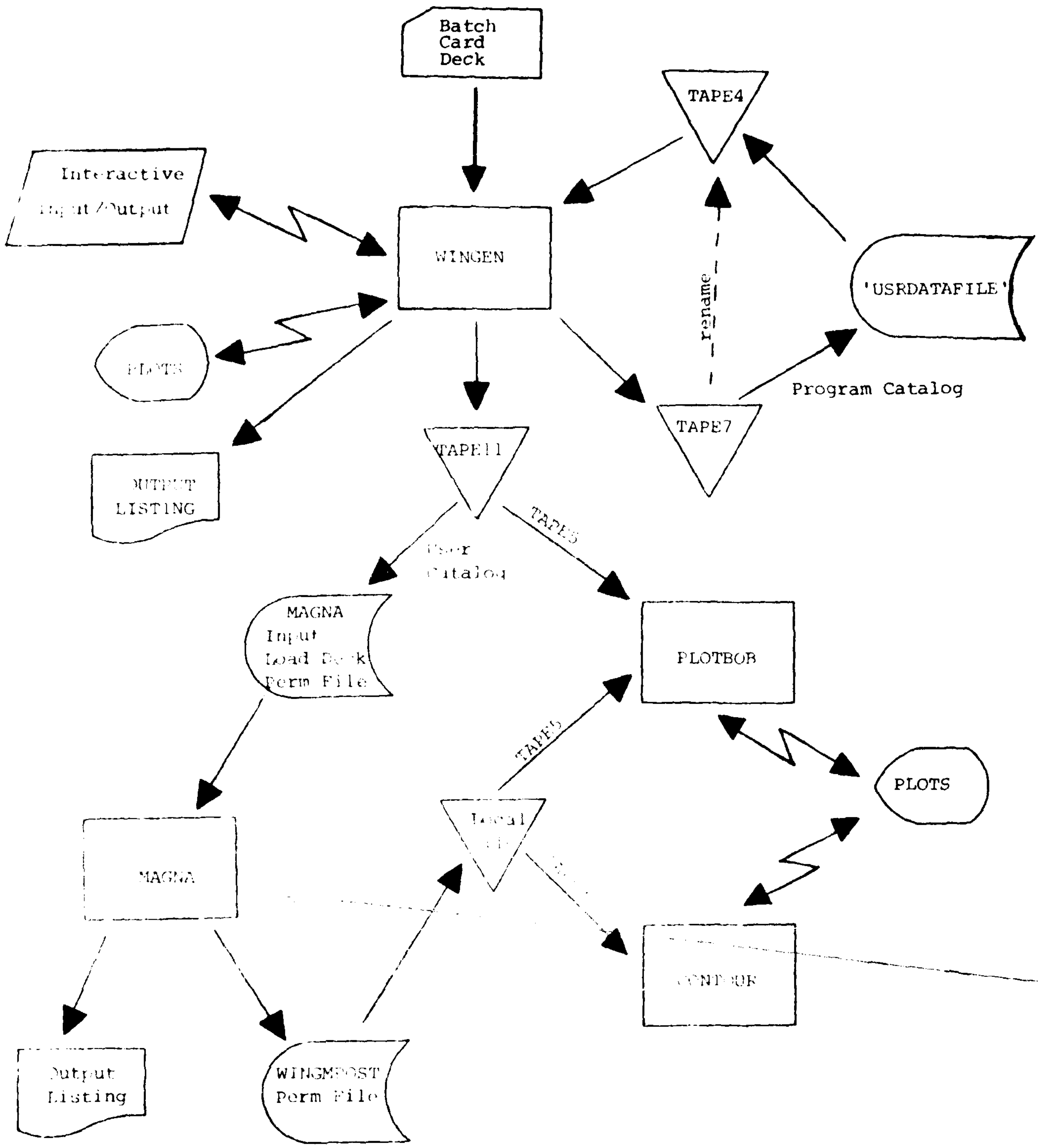


Figure 1.4.1. MODEL development and analysis for wing damage flight loads simulation. This illustrates the interaction of WINGEN, MAGNA, PLOTBOB, and CONTOUR programs in model development, analysis and postprocessing.

SECTION 2
FINITE ELEMENT MODEL PREPROCESSOR

2.1 INTRODUCTION

WINGEN is a convenient and flexible preprocessor computer program designed specifically for the generation of finite element nodes and connectivities input data for damaged and undamaged wing models for the finite element analysis program MAGNA. The program can be run in either the interactive or batch modes. Interactively the model designer can initiate the program and generate an entire data file with simple geometries and basic wing planform dimensions. For batch mode processing an input data file containing this same basic information is required.

In either case of utilizing batch or interactive mode a load deck is created which fully defines the geometry of any one of four classes of wings (see MODEL DEFINITION) with necessary linear constraints, load conditions, finite element boundary conditions, damage specifications, and model mesh refinements over selected areas. In addition, plots illustrating the basic geometry of the wing with labeling of the elements and/or nodes may be generated interactively on a graphics terminal or chart plotter. Capability is currently present that generates 8-node shell elements for upper and lower wing skins and necessary constraints for analysis of a refined mesh model. Figure 2.1.1 illustrates the position WINGEN holds in the process of wing model development.

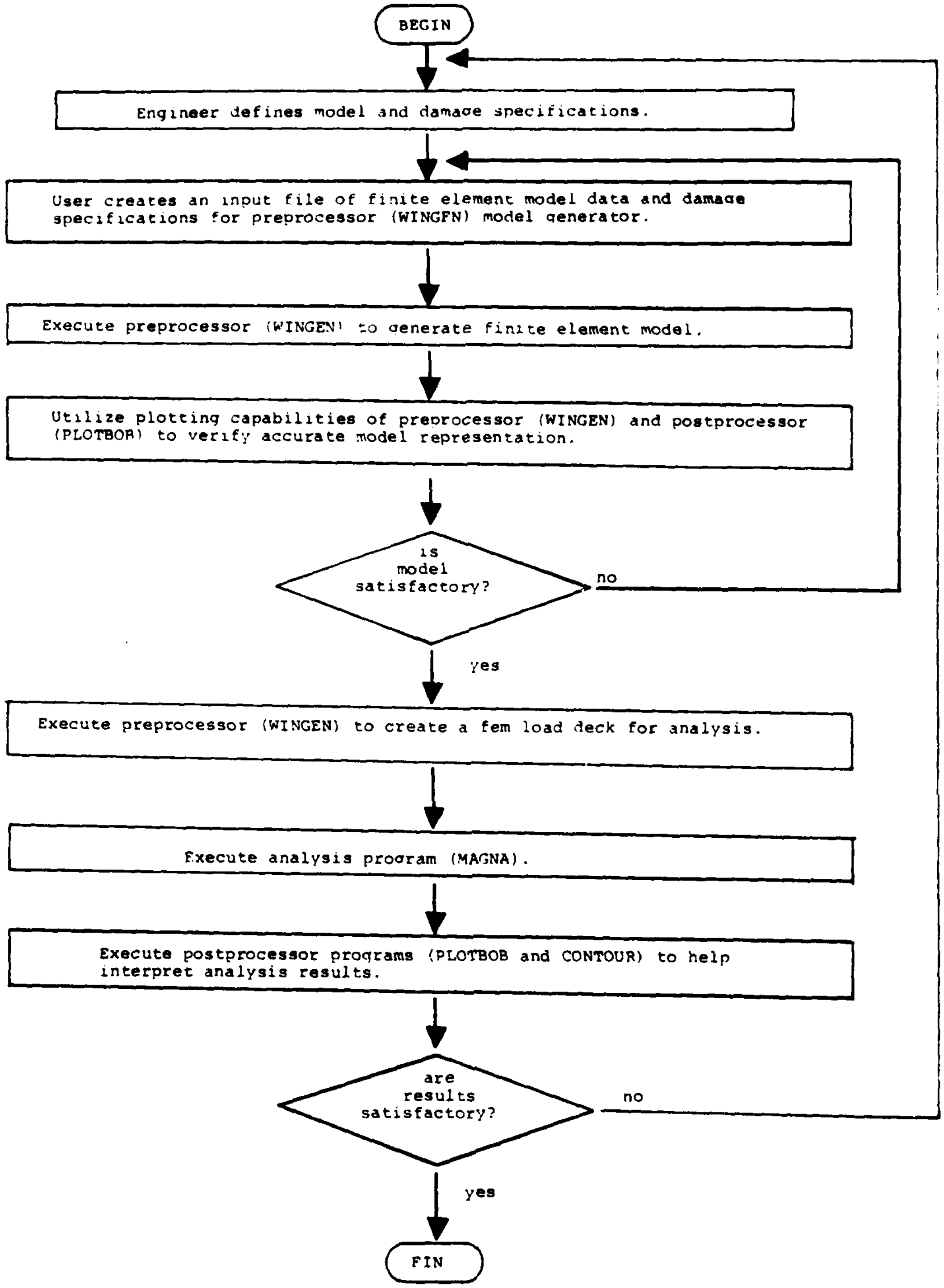


Figure 2.1.1. MODEL definition procedure is outlined here to illustrate the logical steps that are involved in development of an accurate model for the problem on hand.

2.2 WINGEN - PROGRAM ORGANIZATION

The WINGEN preprocessor program is designed to be executed in a batch, interactive or semi-interactive mode. Batch mode use is completely non-interactive and is initiated with cards or a card-image file. Figure 2.2.1 illustrates a sample batch input deck. The important process to be aware of in batch job execution is that all data must be established prior to executing the program and be placed on a permanent disk file accessible to the job or on cards (Figure 2.2.2). The user must catalog the output load deck file for future use. If plots of the basic structure are desired, program PLOTBOB may be executed with the MAGNA input file (load deck). The advantage to using batch mode is that no user interaction is required.

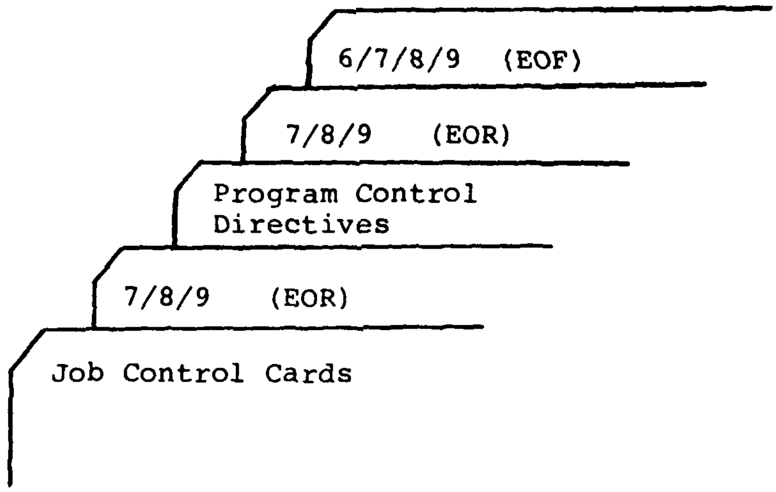
Semi-interactive mode use is accomplished by using a data file established prior to the execution of the program with the information defining the wing formatted as in batch mode input. In this case, however, the program control directives are displayed on the computer terminal and you must answer them as they appear. In addition a number of questions concerning the type of analysis to be done will be requested. The advantage to this type of execution is that it requires considerably less time for the operator to get a load deck than a fully interactive run and one may generate plots of the structure without needing to execute PLOTBOB with the output load deck file, as is required when using batch mode.

Full, interactive use of WINGEN requires the individual to have before him all pertinent data to define the wing. The program will ask all questions and the user must answer with the appropriate piece of information. The program will create and catalog (make a permanent disk file of) the data input by the operator in model definition data format. This file is given the name 'USRDATAFILE' and will be cataloged under the ID which the user logged into the computer with. It must be noted that on the CDC there is a limit of five permanent files

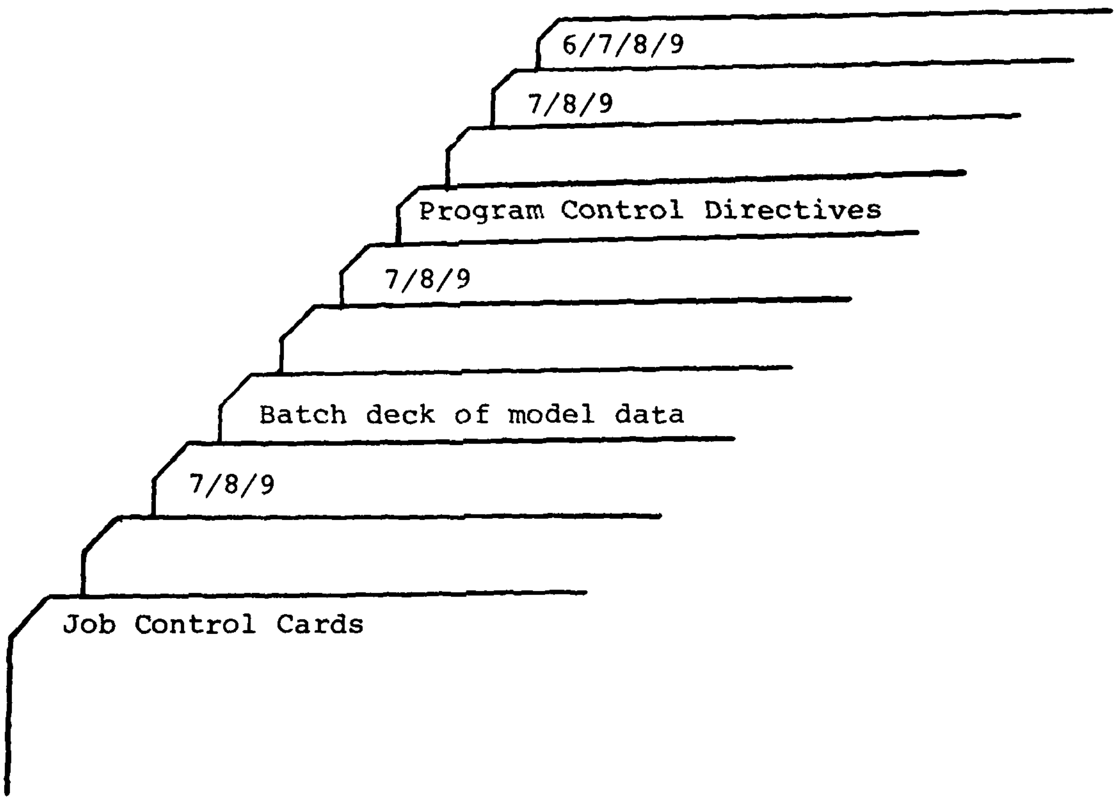
```
XXXX,T2ØØ,IO6ØØ,CM7ØØØØ,STANY. DXXXXXX,DOE,BLDG45,2556666.
ATTACH,F,WINGEN
ATTACH,TAPE5,WINGDATA.
REQUEST,TAPE11,*PF.
F.
CATALOG,TAPE11,WINGINPUT,RP=3ØØ.
7/8/9     (EOR)

N
Y         must be as shown
N
Y
Y         variable controllers
N
XXXX
DXXXXXX,DOE,BLDG48,2556666.
1
1                                   load deck parameters
1
1
7/8/9     (EOR)
6/7/8/9   (EOF)
```

Figure 2.2.1. A sample batch input data deck. File WINGDATA must contain the wing data discussed in Section 2.8.



A. Example of batch job deck for use of a permanent file WINGEN input model deck (batch deck). This deck is listed in Figure 2.2.1.



B. Example of batch job deck for use of a card deck of WINGEN input model data. This deck is listed in Figure 2.2.3.

Figure 2.2.2. Two Examples of Batch Execution for WINGEN.

```
XXXX,T2ØØ,IO6ØØ,CM7ØØØØ,STANY.  DXXXXXX,DOE,BLDG45,2556666.
ATTACH,F,WINGEN.
COPYCR,INPUT,TAPE5.
REWIND,TAPE5.
REQUEST,TAPE11,*PF.
F.
CATALOG,TAPE11,WINGINPUT,RP=3ØØ.
7/8/9      (EOR)


  REPLICA TEST SPECIMEN
PROFILE P1 C1 S1
PLAN      53.88       74.5
DEPTH
     17.75
SKIN       1     1    .25000     .25000
RIBS       5
    2      1     1      0.00       9.30      53.88       9.30
     .1000       .1500
    2      1     1      0.00      19.60      53.88      19.60
     .1000       .1500
    2      1     1      0.00      31.20      53.88      31.20
     .1000       .1500
    2      1     1      0.00      43.90      53.88      43.90
     .1000       .1500
    2      1     1      0.00      59.60      53.88      59.60
     .1000       .1500
SPARS      4
    2      1     1      0.00       0.00       0.00      74.50
     .1875     2.6250
    2      1     1     17.97       0.00      17.97      74.50
     .1250     1.8750
    2      1     1     35.91       0.00      35.91      74.50
     .1250     1.8750
    2      1     1     53.88       0.00      53.88      74.50
     .1875     2.6250
MODIFY
POSTS     -1
                 2     0
    0.0000       .3000
REFINE     1
THICK            1
DAMAGE

7/8/9      (EOR)
N
Y
N
Y
Y
N
XXXX
DXXXXXX,DOE,BLDG45,255-6666.
1
1
1
1
7/8/9      (EOR)
6/7/8/9    (EOF)
```

Figure 2.2.3. Sample Batch Input Deck for Figure 2.2.2b.

(cycles) with the same name, so it is suggested that the user rename the file created to be something more representative of the project being done. (If the program aborts the user may examine local tape file 7 (TAPE7) for correct data and catalog it as a WINGEN input file for batch or semi-interactive use. This may save another lengthy session of interactive use of the program.) The 'USRDATAFILE' generated can then be used as input to WINGEN to create a load deck for input for a MAGNA analysis run. Figure 1.2.1 illustrates a flow chart of the preprocessor operation. Note that a 'USRDATAFILE', which actually formats and echoes the input, a MAGNA input deck (TAPE11) and plots can all be generated in a single execution of WINGEN.

During execution, the program has four processing phases: Control Directive Input; Node and Element Generation; MAGNA Input Deck Creation; and Plotting.

Control Directive Input is requested by the program to determine if the run is interactive or batch, whether or not to create a MAGNA input deck, if shell elements should be used for the upper and lower skins, etc. The input will look as follows:

```
INTERACTIVE RUN? (Y,N)......:
CREATE A LOAD DECK? (Y,N)...:
GENERATE A GRAPH? (Y,N).....:
LIST NODES AND COORDINATES? (Y,N)....:
LIST ELEMENT CONNECTIVITIES? (Y,N)...:
USE SHELL ELEMENTS? (Y,N)............:
```

Once all such questions have been answered the word 'START' will appear and the program will commence with the generation of nodes and element connectivities.

Nodes and Element Connectivities are generated as the primary function of WINGEN. The user may request to have an output listing of this information or may just wish to see the MAGNA input deck that is created at the conclusion of the run.

For complex models the output listing can be very lengthy and the user may find it unnecessary. Options are provided to allow suppression of this output. This phase of WINGEN is also responsible for making modifications to the basic model and implementing damage specifications, refinement directives and necessary linear constraints. It is for this phase that the model definition card input data file is most useful. (Refer to Sections 2.7 and 2.8.)

MAGNA Input Data Deck creation follows the defining of the nodes and elements. The program requests several pieces of information concerning the type of analysis, solution parameters, types and magnitudes of loads applied and other necessary information concerning the execution of the analysis run. If the upper and lower skin meshes of the wing model are refined it is necessary for the user to request the use of three-dimensional shell elements in lieu of the two-dimensional membrane elements used for the basic model. Failure to do this will result in problems arising during the analysis. WINGEN will create a card-image deck containing all the information necessary to initiate a MAGNA analysis run including all job control cards. This data will be placed on local file TAPE11 which the user must catalog if he wishes to save it. Refer to Section 2.9 'WINGEN - LOAD DECK' for further information.

Plotting capabilities of WINGEN are designed to provide the user with a basic definition of the model just generated. The user will find the program prompting for eye position, node and/or element labeling and type of view (orthogonal or perspective). These capabilities provide the necessary graphics capabilities for this type of model development. The program will plot all the elements each time, labeling the nodes or elements as requested. This allows rapid visual verification of the model geometry and the element and node generation. For further reference see Section 2.10 'PLOTTING CAPABILITIES'. Should the user desire more selective plotting and labeling of a model (e.g., for a very complex model) he may take the MAGNA input data deck created by this program (on TAPE11) and execute the PLOTBOB plotting program. PLOTBOB will provide the user with full interactive graphics capabilities including selective element plotting, zoom on model parts, labeling of components, etc. For more information on PLOTBOB see Section 4.2 - 'INTRODUCTION TO PLOTBOB'.

Should the user select shell elements for the upper and lower skins and wish to see plots of the finished model he will have to execute PLOTBOB. WINGEN plots done with the shell elements selected will only illustrate the basic model with membrane elements. This will allow the user an opportunity to verify the model before the more complicated shell elements are generated. The shell elements add such a degree of complexity to model plotting that the requirements for plotting can best be met with the PLOTBOB program.

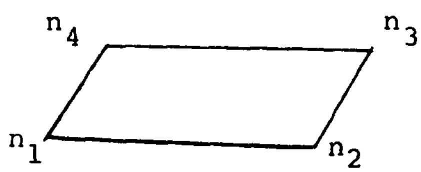
2.3 WINGEN - MODEL DEFINITION

WINGEN is a special-purpose preprocessor for the generation of necessary geometric components of typical wings in a format acceptable to the general purpose finite element analysis program MAGNA. Certain common components have been identified and linked together to allow the rapid generation of a model suitable for efficient and accurate analysis. The basic components of the finite element model (fem) are two-dimensional plane stress (membrane) and shear panel elements, one-dimensional truss elements, and three-dimensional shell elements (MAGNA element types 3, 4 and 5, respectively).

The plane stress element type (element subtype 1 of MAGNA element type 3) is used for the upper and lower skins of the wing model. These must be converted to shell elements (MAGNA element type 5) if the skin areas are refined into a smaller mesh as there will be no constraints or other element connectivities to prevent the nodes from achieving an undesired infinite displacement during analysis. The 3-D nature of shell elements prevents this from occurring. The shear panel element type (element subtype 3 of MAGNA element type 3) is used for definition of the ribs and spars. Upon refinement necessary linear constraints are generated to prevent unreal displacements of newly generated nodes. All type 3 elements require an element number, an element subtype (1 or 3), a material property code (1 or 2), four nodes and a thickness for complete definition. The program predefines two material property codes as these are the most commonly used materials in wing construction.

	LINEAR AND NONLINEAR ANALYSIS	
	Material 1	Material 2
Material	aluminum	steel
Elastic Modulus lb/in^2	$.10*10^8$	$.30*10^8$
Poisson's Ratio	.30	.33
Mass Density lb sec^2/in^4	$.259*10^{-3}$	$.725*10^{-3}$
EQ Stress at 1st Yield lb/in^2	$.10*10^5$	$.30*10^5$
	NONLINEAR ANALYSIS ONLY	
Strain Hardening Curve	1	1
Uniaxial Stress/Strain Data Curve	2	2

The nodal connectivity will be generated by the program for each element, starting at one corner and working completely around:



The program will automatically generate all nodes required to define the geometry and connect these nodes to produce the proper elements for the model definitions. As finite element modeling may be somewhat restrictive a 'MODIFY' command has been included to alter the basic structure generated to produce desired non-uniform changes. The thickness parameter requested for the skins is the average thickness over the entire skin. If thickness of the wing skin changes dramatically it may be necessary to alter the thickness value for the appropriate elements on the MAGNA input file after the preprocessor run is completed. Please note that when a model is refined in the upper and lower skins, shell elements are used to redefine the skins. In the use of shell elements new nodes must be generated. To accomplish the generation of new nodes the program utilizes the upper and lower skin thickness values and generates the new nodes at that displacement from the old nodes, yielding a three-dimensional element with the third dimension being the skin thickness. If the skin thicknesses vary considerably it is advised that the model be generated and the appropriate component (usually the z-component) be altered as needed in the nodal coordinates list of the WINGEN load deck output data file created to accommodate the variations.

The truss element type (MAGNA element type 4) is used to define the rib and spar caps and the vertical posts. The truss element is a one-dimensional element requiring two nodes for its definition along with a material property code and the cross-sectional area of the structure being represented. Listed below are the two material sets predefined by the program for aluminum and steel:

	LINEAR AND NONLINEAR ANALYSIS	
	Material 1	Material 2
Material	aluminum	steel
Elastic Modulus lb/in^4	$.10*10^8$	$.30*10^8$
Mass Density lb sec^2/in^4	$.259*10^{-3}$	$.725*10^{-3}$
EQ Stress at 1st Yield lb/in^2	$.10*10^5$	$.30*10^5$

	NONLINEAR ANALYSIS ONLY	
Strain Hardening Curve	1	1
Uniaxial Stress/ Strain Data Curve	2	2

As with other element types, additional material property codes may be added to the WINGEN load deck output file for additional material used in the wing. For information on how to make this and other modifications to the load deck output file see Section 2.9. The truss element requires only two nodes for its spatial definition:

$$\underline{n_1 \qquad\qquad n_2}$$

The cross-sectional area of the element is obtained by computing the cross-sectional area of the component being represented by the truss element. This is illustrated in Figure 2.3.1.

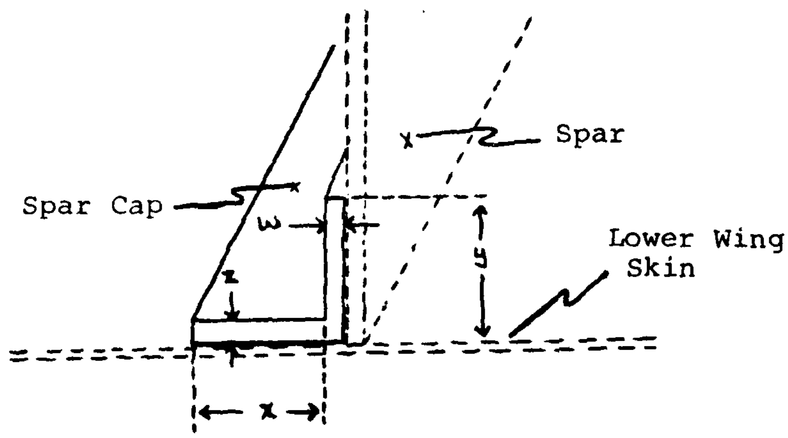


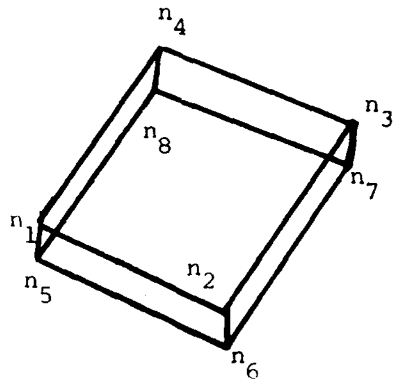
Figure 2.3.1. The cross-sectional area of a truss element (spar and rib caps): (y*w) + (x*z) = area of cross-section.

The 3-D thin shell element type (MAGNA element type 5) is optionally generated to provide a stable model where the basic model has been refined. This is necessary when any new skin nodes generated during refinement are not simultaneously incorporated into rib, spar and skin elements. If shell elements or linear constraints are not utilized in this special case then the newly generated nodes will undergo infinite displacements during the analysis, which will yield undesirable results. The definition of the 3-D thin shell element requires the following information: a) an element number; b) a material property code; and c) eight nodes. The element numbers are supplied by the program. The program automatically substitutes the previous material codes established for the original 2-D membrane element for those codes required in the 3-D element type:

	LINEAR AND NONLINEAR ANALYSIS	
	Material 1	Material 2
Material	aluminum	steel
Elastic Modulus lb/in^2	$.10*10^8$	$.30*10^8$
Poisson's Ratio	.30	.33
Mass Density lb sec^2/in^4	$.259*10^{-3}$	$.725*10^{-3}$

Additional material properties may be added to the WINGEN output file. Further information on this and other changes to the load deck output file may be referenced in Section 2.9 - 'WINGEN - LOAD DECK'.

The nodal connectivity for the thin shell element is illustrated below:



An additional advantage with the 3-D thin shell element is the lack of a need to maintain an even thickness throughout the element. This is the case in the 2-D plane stress element type where there is a uniform thickness across each individual element. The 3-D shell element allows the user the capability of altering the nodal coordinates to arrange for any systematic changes in skin thicknesses.

WINGEN has been designed to accommodate three common profile classes of wings: rectangular, full swept and piecewise linear (see Figure 2.3.2) as well as a general class where the user must identify all nodal coordinates (see P4-C4-S4 profile type in Section 2.8 'WINGEN - MODEL DEFINITION DATA FORMAT'). In the three common profile classes (P1-P3) the preprocessor program will generate all nodes required to define the ribs, spars and skins and derive all necessary nodal connectivities for the basic wing model elements. The general class (P4) model will have all elements and connectivities generated once the nodal coordinates have been supplied. The nodal coordinates are produced by starting at the initially given x and y values and alternating with the generation of a lower skin node first then an upper skin node working chordwise fore to aft, moving to the next rib (in a spanwise direction) and again working chordwise from fore to aft alternating between lower and upper skins generating all nodes for the basic model.

The program then processes any refinement directives, adding nodes as required. In the refinement process the

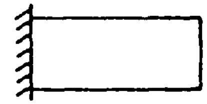
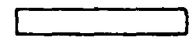
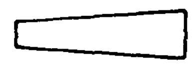
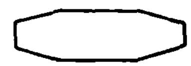
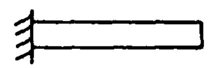
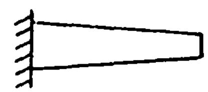
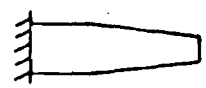
PROFILE	CONFIGURATION CODE	DESCRIPTION	SKETCH
PLANFORM	P1	RECTANGULAR	
	P2	FULL SWEPT	
	P3	PIECEWISE SWEPT	
CHORDWISE	C1	CONSTANT DEPTH	
	C2	LINEAR DEPTH	
	C3	PIECEWISE LINEAR DEPTH	
SPANWISE	S1	CONSTANT DEPTH	
	S2	LINEAR DEPTH	
	S3	PIECEWISE LINEAR DEPTH	

Figure 2.3.2. Wing Profile Classes.

originally numbered nodes are resequenced to allow the newly generated nodes to be incorporated sequentially. This provides for a more comprehensible model when all modifications are concluded. The refinements are generated much the same way as the model was originally defined, with refinement specifications being acted on one at a time. The refinement nodes are added by dividing the difference in the associated coordinates by the number of refinements to be added over that difference. This gives an incremental value which is added to the lower value to successively generate the new nodes. The refine command will always completely traverse the chordwise, spanwise or depthwise bays being refined to ensure element compatibility. (See Figure 2.8.14).

Once the refine directive has been executed all the nodal coordinates will have been defined. The program then processes the damage/modify directives while generating the element connectivities. The damage/modify directives essentially tell the program where to omit elements not relevant to the model. The program establishes a table of damage and modification parameters and searches it to determine if the current element under consideration should be eliminated. If the element meets the criteria established for removal it is not included in the model element list. The modify directive is a special case of the damage directive for use when the model must be altered after using the FEM generator to actually achieve a true representation of the wing. Figure 2.3.3 illustrates this type of situation. There is no processing change in how modify and damage directives are handled by the program.

The generation of the elements follows the same format as the generation of the nodes. The skin elements are generated first starting with the lower skin and alternating between lower and upper skins chordwise (fore to aft) then advancing to the fore location on the next spanwise (root to tip) rib and continuing until all skin elements have been defined.

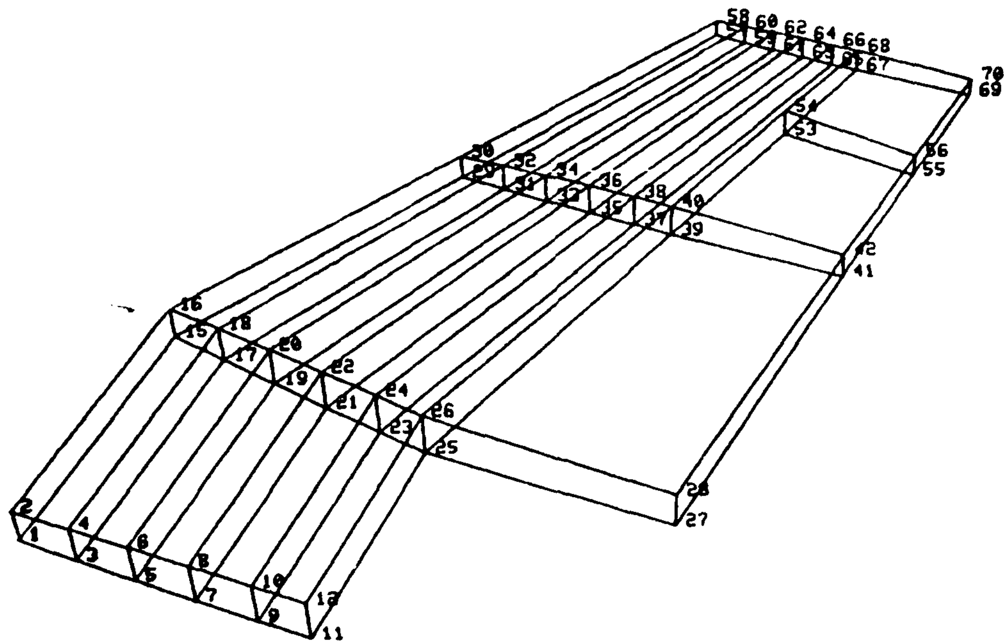


Figure 2.3.3. Example of the MODIFY directive. The area of the wing which would normally contain nodes 13 and 14 has been omitted to accurately represent the model. The short rib at nodes 53-56 was added to the file after preprocessor generation.

Following the skin element definition all the ribs are next defined starting at the root end and proceeding fore to aft chordwise then moving to the next rib spanwise (root to tip) until all ribs have been defined. The spar elements are then generated starting at the foremost rib and working spanwise (from root to tip) then moving chordwise (fore to aft) to the next spar and continuing until all spars have been defined.

Once all type 3 elements have been defined the program progresses to identifying the type 4 elements. This process parallels the defining of the element type 3 ribs and spars described above: first the rib caps are defined starting on the lower skin and alternating between lower and upper skins, moving fore to aft and root to tip (chordwise and spanwise). The spar caps definition begin on the lower skin and alternate between lower and upper skins; moving root to tip and fore to aft (spanwise and chordwise). The last component to be defined are the posts. Posts are vertical elements included to give the structure stability and prevent collapsing of the structure under analytical conditions. These are defined originating at the wing coordinate origin and proceeding chordwise then spanwise until all posts have been defined.

2.4 PROCEDURE FOR EXECUTING WINGEN

To utilize WINGEN one must follow the procedure listed below:

a) LOGIN...

b) ATTACH,TAPE4, (Model Definition data file)] not required for interactive mode

c) ATTACH,F,WINGEN

d) REWIND,F[,TAPE4]

e) ATTACH,LIB,PLOT3D,ID=KING,SN=AFFDL] only required if model geometry plots are desired

f) ATTACH,LIB1,TEKLIB,ID=LIBRARY,SN=ASD]

or ATTACH,LIB1,HPPLOT21,ID=KING,SN=AFFDL]

g) LIBRARY,LIB,LIB1]

h) F.

The above procedure executes a segment loaded binary version of WINGEN. TAPE4 is required for a batch or semi-interactive execution of the program. Data formats and definitions for TAPE4 are given in Sections 2.3 - MODEL DEFINITION and 2.8 - MODEL DEFINITION DATA FORMAT. If no plots of the model geometry are desired then steps e-g above do not have to be executed. These steps serve to attach the plotting routines. Step f above must have the user attach the proper library of plotting routines dependent on the plotting device being utilized. If plots are to be done on a Tektronix graphics terminal or PLOT10 emulator then TEKLIB must be attached, otherwise the user is constrained to plotting on the Hewlett-Packard 7221 plotter and must attach HPPLOT21 instead of TEKLIB. Refer to Section 2.10 - WINGEN PLOTTING CAPABILITIES for more information on plotting. Appendix A illustrates in detail how to execute WINGEN. An alternative method is as follows:

a) LOGIN,....

b) ATTACH,TAPE4,USRDATAFILE

c) ATTACH,PROC,WINGEN,ID=BRUNER,SN=AFFDL

d) BEGIN,WINGEN,PROC. (for Tektronix plots)

or BEGIN,WINGEN,PROC,H. (for Hewlett-Packard plots)

This procedure will execute WINGEN and catalog TAPE11 as WINGINPUT.

2.5 WINGEN OPERATION - PROGRAM INITIATION

Once the program WINGEN has been initiated the user will be prompted by several questions regarding the nature of the processing:

INTERACTIVE RUN? (Y,N)........:
CREATE A LOAD DECK? (Y,N).....:
GENERATE A GRAPH? (Y,N).......:
LIST OF NODES AND COORDINATES? (Y,N).......:
LIST ELEMENT CONNECTIVITIES? (Y,N).........:
USE SHELL ELEMENTS? (Y,N)..................:

These questions serve as the basic controllers of the program and must be answered 'Y' or 'N' for yes or no.

INTERACTIVE RUN? (Y,N) .....:

Requests if the user wishes to input all data into the program dependent on prompting questions from the program (response = 'Y'). Otherwise the program looks for a data file on TAPE4 set up as described later in this report under 'WINGEN - MODEL DEFINITION DATA FORMAT' (response = 'N').

CREATE A LOAD DECK? (Y,N).....:

Should the user response 'Y' to this question an input file fully formatted with CDC job control cards and all data necessary for a MAGNA FEM (finite element model) analysis will be created. TAPE11 will contain this information at the conclusion of the run. It is up to the user to save the TAPE11 file as a permanent file for later use. An 'N' response prevents a load deck from being created. Please note: if shell elements are selected, a load deck will be created regardless of the response to this question and the user will need to utilize PLOTBOB postprocessing program to obtain model geometry plots of the structure defined on TAPE11.

GENERATE A GRAPH? (Y,N).....:

WINGEN has limited plotting capability which can generate the complete structure with any viewing position and with or without nodes and elements labeled. The user must have access to a Tektronix or other device utilizing PLOT1Ø graphics software or a Hewlett-Packard utilizing HPPLOT21 library subroutines to make use of the graphics capability of the program. Further information is detailed in Section 2.10 'WINGEN - PLOTTING CAPABILITIES'.

USE SHELL ELEMENTS? (Y,N).....:

Shell elements (MAGNA element type 5) are an optional substitution for the membrane plate elements (MAGNA element type 3 subtype 1) used for the upper and lower skins of the wing. These are used in the event the user is interested in refining the element mesh to be finer than the basic geometry defined. The use of shell elements eliminates the need for linear constraints to be generated for all skin nodes not bound by geometric restrictions imposed by being situated at the junction of rib, spar, and skin elements. If the model is refined such that more than two nodes are required to define the thickness through any part of the structure the program will generate linear constraints to prevent unrealistic displacements to occur during analysis. Shell elements should be requested for damaged models as well as refined models for more accurate analysis results.

Two options control the suppression of output listing of nodal components and element connectivities. This is for the case where the terminal operator is not concerned with getting an immediate listing of the node and element data and may elect instead to examine the FEM input data stored on TAPE11 following the WINGEN run.

LIST NODES AND COORDINATES? (Y,N).....:

LIST ELEMENT CONNECTIVITIES? (Y,N)....:

An 'N' response to either of these questions will inhibit the printing of the appropriate material at the terminal.

2.6 WINGEN - INTERACTIVE MODE

WINGEN has the capability for fully interactive wing model generation. This interactive mode requires no predefined data sets although the user must have all data necessary to define the model available for the terminal session. The data required is defined in detail in Section 2.8 - MODEL DEFINITION DATA FORMAT. WINGEN will prompt the user with questions such as those illustrated in Figure 2.6.1 where the underlined values represent responses to the questions prompted by the program. All information requested by the program follows the same sequence of input as described for the Model Definition data format. The questions were designed to guide the user as much as possible in understanding what information is being requested. A glossary is provided for terms which are utilized in this report or are contained in questions prompted by the program in the event the questions are insufficient for the user to understand what is being requested. Once all the questions pertaining to the model definition have been answered, the program will build a WINGEN input data file from the parameters input by the user. If a load deck was requested, the program will then initiate further questions as described in Section 2.9 to define the loaded nodes, fixed nodes and analysis parameters for MAGNA. Finally, if plots were requested, the program will prompt the user with the necessary commands to generate the model just defined. The plotting capabilities of WINGEN are fully described in Section 2.10.

Interactive mode is initiated as described in Section 2.5. The program will request several control directives to be input by the user such as:

```
INTERACTIVE RUN? (Y,N)....................:
CREATE A LOAD DECK? (Y,N).................:
GENERATE A GRAPH? (Y,N)...................:
DO YOU WANT A LISTING OF NODAL COORDINATES? (Y,N)......:
DO YOU WANT A LISTING OF ELEMENT CONNECTIVITY? (Y,N)...:
USE SHELL ELEMENTS? (Y,N)...............................:
```

```
START


ENTER PROBLEM TITLE...................: T-38 WING MODEL DEFINITION


WING PROFILE PARAMETERS-
  1.PLANFORM SHAPE CODE:1-RECTANGULAR
                        2-FULL SWEPT
                        3-PIECEWISE LINEAR
                        4-GENERAL
   ENTER PLANFORM SHAPE CODE(1,2,3,4)....: 3
  2.CHORD DEPTH DISTRIBUTION CODE:1-CONSTANT DEPTH
                                  2-LINEAR DEPTH
                                  3-PIECEWISE LINEAR
                                  4-GENERAL
   ENTER CHORD DEPTH DISTRIBUTION CODE(1,2,3,4): 3
  3. SPANWISE DEPTH DISTRIBUTION CODE:1-CONSTANT DEPTH
                                      2-LINEAR DEPTH
                                      3-PIECEWISE LINEAR
                                      4-GENERAL
   ENTER SPANWISE DEPTH DISTRIBUTION CODE(1,2,3,4): 3


PIECEWISE LINEAR PLANFORM
   ENTER NUMBER OF SPANWISE STATIONSTO BE USED
   IN DEFINING PLANFORM SHAPE............: 4

PLANFORM GEOMETRY DATA
   X IS MEASURED FROM L.E.ROOT,POSITIVE AFT
   Y IS MEASURED FROM L.E. ROOT,POSITIVE OUTBOARD
 PLANFORM STATION NUMBER-    1
   ENTER X AND Y COORDINATES FOR LEADING
   EDGE..................................: 0. 0.
   ENTER X AND Y COORDINATES FOR TRAILING
   EDGE..................................: 58.48 0.
 PLANFORM STATION NUMBER-    2
   ENTER X AND Y COORDINATES FOR LEADING
   EDGE..................................: 0. 29.92
   ENTER X AND Y COORDINATES FOR TRAILING
   EDGE..................................: 57.9 25.23
 PLANFORM STATION NUMBER-    3
   ENTER X AND Y COORDINATES FOR LEADING
   EDGE..................................: 18.14 84.8
```

Figure 2.6.1. Sample of Interactive Mode Questions.

The user must respond 'Y' to the question - Interactive Run? This will direct questions to the user's terminal requesting input of necessary data for defining the model. The remaining control directives may be answered depending on the user's wishes. Once the program issues a 'START' line, the interactive mode has been engaged and questions will be displayed requesting input data.

The input data required by the preprocessor falls into twelve categories:

1. Program title
2. Profile definition
3. Planform description
4. Chordwise description
5. Spanwise description
6. Rib definitions
7. Span definitions
8. Modifications to basic model
9. Post definitions
10. Refinement directives
11. Damage specifications
12. Loads to be applied

These 12 categories are followed sequentially while the program requests data and defines the model. Each of these categories is fully explained and all values are defined in Section 2.8. The user should refer to that section for more detailed information concerning the data requested by the program. Once the data has been fully input, the program will catalog the data under the name'USRDATAFILE'. This file may be attached as a preprocessor input data file (TAPE4) and used to generate the same model in later executions of WINGEN or modified and used to generate a new model. This file is illustrated in Figure 2.6.3. The user should be aware that a maximum of five permanent files with the same name (cycles) are allowed on the CDC. If repeated use of the interactive mode is made, the user will have to ensure there is a cycle available on which to store the data file. Should there be any problem (a PF abort, for instance), all the model data for WINGEN input is contained on TAPE7 at the conclusion of the program execution. The user may catalog TAPE7 with a different permanent file name at the conclusion of the program run. Figure 2.6.2 illustrates the T-38 wing. The appendices provide examples of attaching and executing WINGEN to make use of the various processing options.

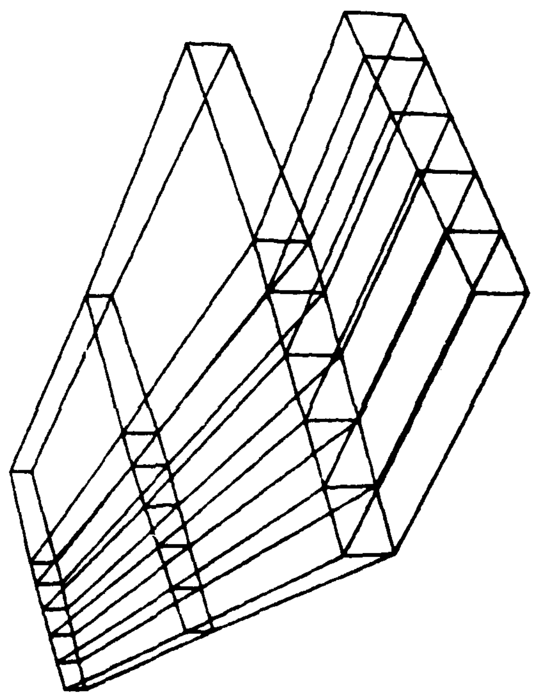


Figure 2.6.2. T-38 Wing Model Generated Interactively.

```
        T38 -WING SPECIMEN-
PROFILE P3 C3 S3
PLAN         4
        00.00      00.00      58.48      00.00
        00.00      29.92      57.95      25.23
        18.14      64.80      63.86      64.80
        36.82     101.00      69.27     101.00
DEPTH        4      4
        00.00      00.00       4.32
        25.90      00.00       5.18
        31.55      00.00       5.15
        58.48      00.00       4.38
        00.00      29.92       4.32
        26.03      26.07       5.18
        31.55      25.26       5.15
        58.48      25.23       4.38
        18.14      64.80       2.75
        30.37      64.80       3.75
        43.83      64.80       3.75
        63.86      64.80       2.92
        36.82     101.00       2.34
        51.92     101.00       3.08
        56.06     101.00       3.08
        69.27     101.00       2.62
SKIN         1      1      0.167      0.153
RIBS         4
      1      1      0      00.00      00.00      31.56      00.00
           .10         .15
      1      1      0      00.00      29.92      57.95      25.23
           .10         .15
      2      1      2      18.14      64.80      63.86      64.80
           .10         .15
      1      1      0      36.82     101.00      69.27     101.00
           .10         .15
SPARS        7
      1      1      0      00.00      00.00      36.82     101.00
         .0001       .0001
      1      1      0       6.39      00.00      40.60     101.00
         .0001       .0001
      1      1      0      12.85      00.00      44.37     101.00
         .0001       .0001
      1      1      0      19.38      00.00      48.14     101.00
         .0001       .0001
      1      1      0      25.99      00.00      51.92     101.00
         .0001       .0001
      1      1      0      31.55      00.00      56.06     101.00
         .0001       .0001
      1      1      0      58.48      00.00      69.27     101.00
         .0001       .0001
MODIFY       1
LOCAT                                58.        0.0       25.0
POSTS       -1
                    8     0
                        .30
REFINE       1
SPAN                1
DAMAGE
LOADS        1
CENTER       0
TEST
           0.0        0.0                .25E6        0.0        0.0
```

Figure 2.6. 3. Listing of the data file created by WINGEN on TAPE7 of the input model data from an interactive program execution.

2.7 WINGEN SEMI-INTERACTIVE MODE

Capability has been provided for a "semi-interactive" mode of utilization of the preprocessor program WINGEN. This mode differentiates between interactive and batch modes in that it allows the user the advantages of building a batch input data file for model definition and permits the user the advantage of graphic verification of the model geometry without a lengthy terminal session. The semi-interactive mode is utilized by first creating a model data file as defined in Section 2.8 and saving the file or attaching a cataloged file as a local file - TAPE4. The user then follows the procedure listed in Section 2.5 to initiate WINGEN. The user must respond 'N' to the question "Interactive Run?" All required model definition data will be taken from TAPE4. Once the model has been defined, the program will request information for the creation of a load deck, if one was requested, then it will request information for plotting parameters, if graphs were requested. The user may refer to Sections 2.9 and 2.10, respectively, for further information on load decks and plotting capabilities of WINGEN. Figure 2.7.1 illustrates a semi-interactive mode execution of WINGEN utilizing the model definition (batch input) data format file illustrated in Figure 2.7.2 to generate the model illustrated in Figure 2.7.3.

```
INTERACTIVE RUN?(Y,N)....................: N
CREATE A LOAD DECK?(Y,N)................: Y
GENERATE A GRAPH?(Y,N)..................: N
DO YOU WANT A LISTING OF NODAL COORDINATES?(Y,N)...: Y
DO YOU WANT A LISTING OF ELEMENT CONNECTIVITY?(Y,N): Y
USE SHELL ELMENTS FOR TOP & BOTTOM SKIN?(Y,N)......: N


START



     FLIGHT LOADS SIMULATION   MODEL GENERATOR

       REPLICA TEST SPECIMEN


     WING PROFILE PARAMETERS :


          PLANFORM SHAPE  1    (RECTANGULAR)
          CHORDWISE SHAPE 1    (CONSTANT DEPTH)
          SPANWISE SHAPE  1    (CONSTANT DEPTH)



     SUMMARY OF PLANFORM DEPTH DISTRIBUTION
     (INCLUDES GENERATED POINTS)

     SPAN STATION  1
     POINT      X          Y        DEPTH
       1      0.0000     0.0000    17.7500
       2     53.2800     0.0000    17.7500

     SPAN STATION  2
     POINT      X          Y        DEPTH
       1      0.0000    74.5000    17.7500
       2     53.2800    74.5000    17.7500


     FLIGHT LOADS SIMULATION   MODEL GENERATOR

       REPLICA TEST SPECIMEN
```

Figure 2.7.1. A semi-interactive execution of WINGEN using the input data file created by an interactive execution of the program. The input data file is listed in Figure 2.7.2 while the model generated is illustrated in Figure 2.7.3.

```
RIB AND RIB-CAP PARAMETERS :
RIB NO    MATL   CAP MATL  SECT   DIMENSIONS
   1        2         1     1      0.00     9.30    53.88     9.30
                                   .1000    .1500   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
   2        2         1     1      0.00    19.60    53.88    19.60
                                   .1000    .1500   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
   3        2         1     1      0.00    31.20    53.88    31.20
                                   .1000    .1500   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
   4        2         1     1      0.00    43.90    53.88    43.90
                                   .1000    .1500   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
   5        2         1     1      0.00    59.60    53.88    59.60
                                   .1000    .1500   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

FLIGHT LOADS SIMULATION   MODEL GENERATOR

  REPLICA TEST SPECIMEN

SPAR AND SPAR-CAP PARAMETERS :
SPAR NO   MATL   CAP MATL  SECT   DIMENSIONS
   1        2         1     1      0.00     0.00     0.00    74.50
                                   .1875   2.6250   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
   2        2         1     1     17.97     0.00    17.97    74.50
                                   .1250   1.8750   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
   3        2         1     1     35.91     0.00    35.91    74.50
                                   .1250   1.8750   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
   4        2         1     1     53.88     0.00    53.88    74.50
                                   .1875   2.6250   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

FLIGHT LOADS SIMULATION   MODEL GENERATOR

  REPLICA TEST SPECIMEN

POST PARAMETERS :
POST NO  MATL  CHORD-SPAN  DIMENSIONS

           2
                                 0.0000    .3000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

FLIGHT LOADS SIMULATION   MODEL GENERATOR
NODE POINTS FOR COMPLETE MODEL

 NODE      X          Y          Z
   1      0.0000     0.0000    -8.8750
   2      0.0000     0.0000     8.8750
   3     17.9700     0.0000    -8.8750
   4     17.9700     0.0000     8.8750
   5     35.9100     0.0000    -8.8750
   6     35.9100     0.0000     8.8750
   7     53.8800     0.0000    -8.8750
   8     53.8800     0.0000     8.8750
   9      0.0000     9.3000    -8.8750
  10      0.0000     9.3000     8.8750
  11     17.9700     9.3000    -8.8750
  12     17.9700     9.3000     8.8750
  13     35.9100     9.3000    -8.8750
```

Figure 2.7.1. (continued).

14	35.9100	9.3000	8.8750
15	53.8800	9.3000	-8.8750
16	53.8800	9.3000	8.8750
17	0.0000	19.6000	-8.8750
18	0.0000	19.6000	8.8750
19	17.9700	19.6000	-8.8750
20	17.9700	19.6000	8.8750
21	35.9100	19.6000	-8.8750
22	35.9100	19.6000	8.8750
23	53.8800	19.6000	-8.8750
24	53.8800	19.6000	8.8750
25	0.0000	31.2000	-8.8750
26	0.0000	31.2000	8.8750
27	17.9700	31.2000	-8.8750
28	17.9700	31.2000	8.8750
29	35.9100	31.2000	-8.8750
30	35.9100	31.2000	8.8750
31	53.8800	31.2000	-8.8750
32	53.8800	31.2000	8.8750
33	0.0000	43.9000	-8.8750
34	0.0000	43.9000	8.8750
35	17.9700	43.9000	-8.8750
36	17.9700	43.9000	8.8750
37	35.9100	43.9000	-8.8750
38	35.9100	43.9000	8.8750
39	53.8800	43.9000	-8.8750
40	53.8800	43.9000	8.8750
41	0.0000	59.6000	-8.8750
42	0.0000	59.6000	8.8750
43	17.9700	59.6000	-8.8750
44	17.9700	59.6000	8.8750
45	35.9100	59.6000	-8.8750
46	35.9100	59.6000	8.8750
47	53.8800	59.6000	-8.8750
48	53.8800	59.6000	8.8750
49	0.0000	74.5000	-8.8750
50	0.0000	74.5000	8.8750
51	17.9700	74.5000	-8.8750
52	17.9700	74.5000	8.8750
53	35.9100	74.5000	-8.8750
54	35.9100	74.5000	8.8750
55	53.8800	74.5000	-8.8750
56	53.8800	74.5000	8.8750

FLIGHT LOADS SIMULATION MODEL GENERATOR

REPLICA TEST SPECIMEN

DAMAGE PARAMETERS

N	EL.TYPE	SURF.		BAY1	BAY2	X	Y	RAD.
1	SKINL	1	1	4	2	0.00	0.00	0.00

FLIGHT LOADS SIMULATION MODEL GENERATOR
ELEMENT DEFINITIONS

TYPE	NNOD	ELNO	N1	N2	N3	N4	MATL	THICKNESS
1	4	1	1	3	11	9	1	.250000
1	4	2	2	4	12	10	1	.250000

Figure 2.7.1. (continued).

1	4	3	3	5	13	11	1	.250000
1	4	4	4	6	14	12	1	.250000
1	4	5	5	7	15	13	1	.250000
1	4	6	6	8	16	14	1	.250000
1	4	7	9	11	19	17	1	.250000
1	4	8	10	12	20	18	1	.250000
1	4	9	11	13	21	19	1	.250000
1	4	10	12	14	22	20	1	.250000
1	4	11	13	15	23	21	1	.250000
1	4	12	14	16	24	22	1	.250000
1	4	13	17	19	27	25	1	.250000
1	4	14	18	20	28	26	1	.250000
1	4	15	19	21	29	27	1	.250000
1	4	16	20	22	30	28	1	.250000
1	4	17	21	23	31	29	1	.250000
1	4	18	22	24	32	30	1	.250000
1	4	19	25	27	35	33	1	.250000
1	4	20	26	28	36	34	1	.250000
1	4	21	28	30	38	36	1	.250000
1	4	22	29	31	39	37	1	.250000
1	4	23	30	32	40	38	1	.250000
1	4	24	33	35	43	41	1	.250000
1	4	25	34	36	44	42	1	.250000
1	4	26	35	37	45	43	1	.250000
1	4	27	36	38	46	44	1	.250000
1	4	28	37	39	47	45	1	.250000
1	4	29	38	40	48	46	1	.250000
1	4	30	41	43	51	49	1	.250000
1	4	31	42	44	52	50	1	.250000
1	4	32	43	45	53	51	1	.250000
1	4	33	44	46	54	52	1	.250000
1	4	34	45	47	55	53	1	.250000
1	4	35	46	48	56	54	1	.250000
2	4	36	9	11	12	10	2	.100000
2	4	37	11	13	14	12	2	.100000
2	4	38	13	15	16	14	2	.100000
2	4	39	17	19	20	18	2	.100000
2	4	40	19	21	22	20	2	.100000
2	4	41	21	23	24	22	2	.100000
2	4	42	25	27	28	26	2	.100000
2	4	43	27	29	30	28	2	.100000
2	4	44	29	31	32	30	2	.100000
2	4	45	33	35	36	34	2	.100000
2	4	46	35	37	38	36	2	.100000
2	4	47	37	39	40	38	2	.100000
2	4	48	41	43	44	42	2	.100000
2	4	49	43	45	46	44	2	.100000
2	4	50	45	47	48	46	2	.100000
3	4	51	1	9	10	2	2	.187500
3	4	52	9	17	18	10	2	.187500
3	4	53	17	25	26	18	2	.187500
3	4	54	25	33	34	26	2	.187500
3	4	55	33	41	42	34	2	.187500
3	4	56	41	49	50	42	2	.187500
3	4	57	3	11	12	4	2	.125000
3	4	58	11	19	20	12	2	.125000
3	4	59	19	27	28	20	2	.125000
3	4	60	27	35	36	28	2	.125000
3	4	61	35	43	44	36	2	.125000
3	4	62	43	51	52	44	2	.125000
3	4	63	5	13	14	6	2	.125000
3	4	64	13	21	22	14	2	.125000
3	4	65	21	29	30	22	2	.125000
3	4	66	29	37	38	30	2	.125000

Figure 2.7.1. (continued).

3	4	67	37	45	46	38	2	.125000
3	4	68	45	53	54	46	2	.125000
3	4	69	7	15	16	8	2	.187500
3	4	70	15	23	24	16	2	.187500
3	4	71	23	31	32	24	2	.187500
3	4	72	31	39	40	32	2	.187500
3	4	73	39	47	48	40	2	.187500
3	4	74	47	55	56	48	2	.187500
4	2	75	9	11	0	1	1	.150000
4	2	76	10	12	0	1	1	.150000
4	2	77	11	13	0	1	1	.150000
4	2	78	12	14	0	1	1	.150000
4	2	79	13	15	0	1	1	.150000
4	2	80	14	16	0	1	1	.150000
4	2	81	17	19	0	1	1	.150000
4	2	82	18	20	0	1	1	.150000
4	2	83	19	21	0	1	1	.150000
4	2	84	20	22	0	1	1	.150000
4	2	85	21	23	0	1	1	.150000
4	2	86	22	24	0	1	1	.150000
4	2	87	25	27	0	1	1	.150000
4	2	88	26	28	0	1	1	.150000
4	2	89	27	29	0	1	1	.150000
4	2	90	28	30	0	1	1	.150000
4	2	91	29	31	0	1	1	.150000
4	2	92	30	32	0	1	1	.150000
4	2	93	33	35	0	1	1	.150000
4	2	94	34	36	0	1	1	.150000
4	2	95	35	37	0	1	1	.150000
4	2	96	36	38	0	1	1	.150000
4	2	97	37	39	0	1	1	.150000
4	2	98	38	40	0	1	1	.150000
4	2	99	41	43	0	1	1	.150000
4	2	100	42	44	0	1	1	.150000
4	2	101	43	45	0	1	1	.150000
4	2	102	44	46	0	1	1	.150000
4	2	103	45	47	0	1	1	.150000
4	2	104	46	48	0	1	1	.150000
5	2	105	1	9	0	1	1	2.625000
5	2	106	2	10	0	1	1	2.625000
5	2	107	9	17	0	1	1	2.625000
5	2	108	10	18	0	1	1	2.625000
5	2	109	17	25	0	1	1	2.625000
5	2	110	18	26	0	1	1	2.625000
5	2	111	25	33	0	1	1	2.625000
5	2	112	26	34	0	1	1	2.625000
5	2	113	33	41	0	1	1	2.625000
5	2	114	34	42	0	1	1	2.625000
5	2	115	41	49	0	1	1	2.625000
5	2	116	42	50	0	1	1	2.625000
5	2	117	3	11	0	1	1	1.875000
5	2	118	4	12	0	1	1	1.875000
5	2	119	11	19	0	1	1	1.875000
5	2	120	12	20	0	1	1	1.875000
5	2	121	19	27	0	1	1	1.875000
5	2	122	20	28	0	1	1	1.875000
5	2	123	27	35	0	1	1	1.875000
5	2	124	28	36	0	1	1	1.875000
5	2	125	35	43	0	1	1	1.875000
5	2	126	36	44	0	1	1	1.875000
5	2	127	43	51	0	1	1	1.875000
5	2	128	44	52	0	1	1	1.875000
5	2	129	5	13	0	1	1	1.875000
5	2	130	6	14	0	1	1	1.875000

Figure 2.7.1. (continued).

```
5   2  131  13  21   0   1   1   1.875000
5   2  132  14  22   0   1   1   1.875000
5   2  133  21  29   0   1   1   1.875000
5   2  134  22  30   0   1   1   1.875000
5   2  135  29  37   0   1   1   1.875000
5   2  136  30  38   0   1   1   1.875000
5   2  137  37  45   0   1   1   1.875000
5   2  138  38  46   0   1   1   1.875000
5   2  139  45  53   0   1   1   1.875000
5   2  140  46  54   0   1   1   1.875000
5   2  141   7  15   0   1   1   2.625000
5   2  142   8  16   0   1   1   2.625000
5   2  143  15  23   0   1   1   2.625000
5   2  144  16  24   0   1   1   2.625000
5   2  145  23  31   0   1   1   2.625000
5   2  146  24  32   0   1   1   2.625000
5   2  147  31  39   0   1   1   2.625000
5   2  148  32  40   0   1   1   2.625000
5   2  149  39  47   0   1   1   2.625000
5   2  150  40  48   0   1   1   2.625000
5   2  151  47  55   0   1   1   2.625000
5   2  152  48  56   0   1   1   2.625000
6   2  153   9  10   0   0   2    .300000
6   2  154  11  12   0   0   2    .300000
6   2  155  13  14   0   0   2    .300000
6   2  156  15  16   0   0   2    .300000
6   2  157  17  18   0   0   2    .300000
6   2  158  19  20   0   0   2    .300000
6   2  159  21  22   0   0   2    .300000
6   2  160  23  24   0   0   2    .300000
6   2  161  25  26   0   0   2    .300000
6   2  162  27  28   0   0   2    .300000
6   2  163  29  30   0   0   2    .300000
6   2  164  31  32   0   0   2    .300000
6   2  165  33  34   0   0   2    .300000
6   2  166  35  36   0   0   2    .300000
6   2  167  37  38   0   0   2    .300000
6   2  168  39  40   0   0   2    .300000
6   2  169  41  42   0   0   2    .300000
6   2  170  43  44   0   0   2    .300000
6   2  171  45  46   0   0   2    .300000
6   2  172  47  48   0   0   2    .300000
FIXED NODES..........:    8

   1    2    3    4    5    6    7    8

LOADED NODES..........:    8

  49   50   51   52   53   54   55   56


ENTER JOB CARD ID......................: UDSK
ENTER JOB CARD COMMENT
(PROBLEM NO.,NAME,SYMBOL,ETC.).........: [redacted],BRUNER,RI566,2293018.
MATERIAL NONLINEARITIES FLAG :
  1 -ELASTIC (LINEAR) ANALYSIS
  2 -PLASTIC (NONLINEAR) ANALYSIS
ENTER MATERIAL NONLINEARITIES FLAG.....: 1
GEOMETRIC NONLINEARITIES FLAG :
  1 -SMALL DISPLACEMENT (LINEAR) ANALYSIS
  2 -LARGE DISPLACEMENT (NONLINEAR) ANALYSIS
```

Figure 2.7.1.   (continued).

```
ENTER GEOMETRIC NONLINEARITIES FLAG....! 1
ENTER THE NUMBER OF LOAD STEPS TO BE
PERFORMED IN THE SOLUTION............! 1
ENTER LOAD INCREMENT STEP SIZE.........! 1

      FLIGHT LOADS SIMULATION   MODEL GENERATOR

        REPLICA TEST SPECIMEN

      LOADS PARAMETERS
       N  TYPE       ALPHA
       1 TEST            0.00
              FX          FY          FZ          MS          MT          MC
              0.          0.          0.  2000000.            0.          0.
     CENTER OF LOADED PLANE
              XC          YC          ZC
           26.94       74.50        0.00

      LOADS APPLIED TO TIP NODES
       NODE        FX          FY          FZ
         49        0.      18790.          0.
         50        0.     -18790.          0.
         51        0.      37540.          0.
         52        0.     -37540.          0.
         53        0.      37540.          0.
         54        0.     -37540.          0.
         55        0.      18790.          0.
         56        0.     -18790.          0.
   STOP
    1.160 CP SECONDS EXECUTION TIME
COMMAND-
```

Figure 2.7.1. (continued).

```
  REPLICA TEST SPECIMEN
PROFILE P1 C1 S1
PLAN      53.88      74.5
DEPTH
     17.75
SKIN       1      1    .25000    .25000
RIBS       5
    2      1      1     0.00      9.30     53.88      9.30
       .1000       .1500
    2      1      1     0.00     19.60     53.88     19.60
       .1000       .1500
    2      1      1     0.00     31.20     53.88     31.20
       .1000       .1500
    2      1      1     0.00     43.90     53.88     43.90
       .1000       .1500
    2      1      1     0.00     59.60     53.88     59.60
       .1000       .1500
SPARS      4
    2      1      1     0.00      0.00      0.00     74.50
       .1875      2.6250
    2      1      1    17.97      0.00     17.97     74.50
       .1250      1.8750
    2      1      1    36.91      0.00     36.91     74.50
       .1250      1.8750
    2      1      1    53.88      0.00     53.88     74.50
       .1875      2.6250
MODIFY
POSTS     -1
                  2     0
      0.0000       .3000
REFINE
DAMAGE     1
SKINL             4     2
LOADS      1
CENTER     0
TEST
       0.0       0.0              2.E6       0.0       0.0
..
```

Figure 2.7.2. The batch mode data format file used to make the preprocessor run listed in Figure 2.7.1 for the model illustrated in Figure 2.7.3.

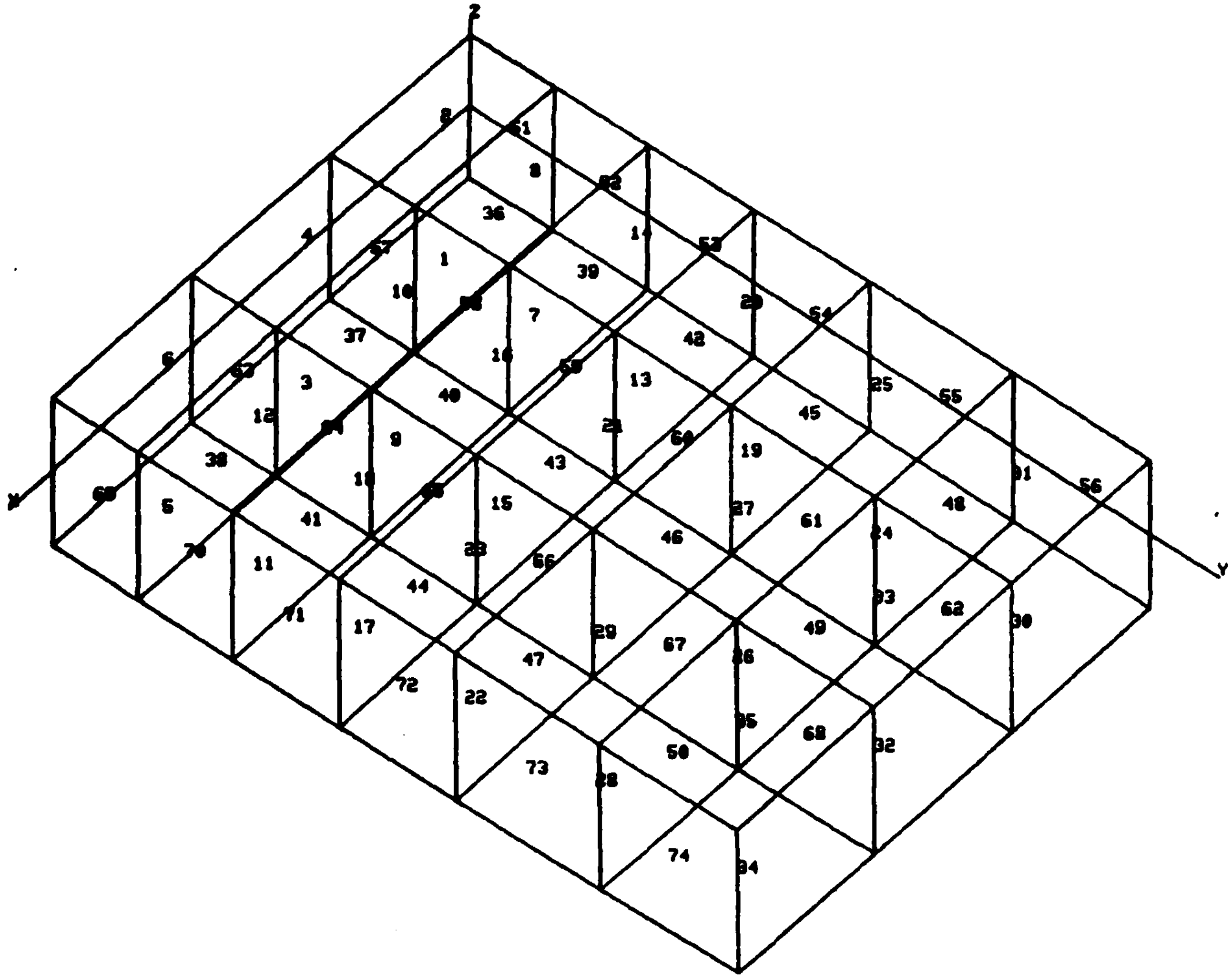


Figure 2.7.3. Model generated with the input batch mode data format illustrated in Figure 2.7.2 during the semi-interactive execution of the program listed in Figure 2.7.1.

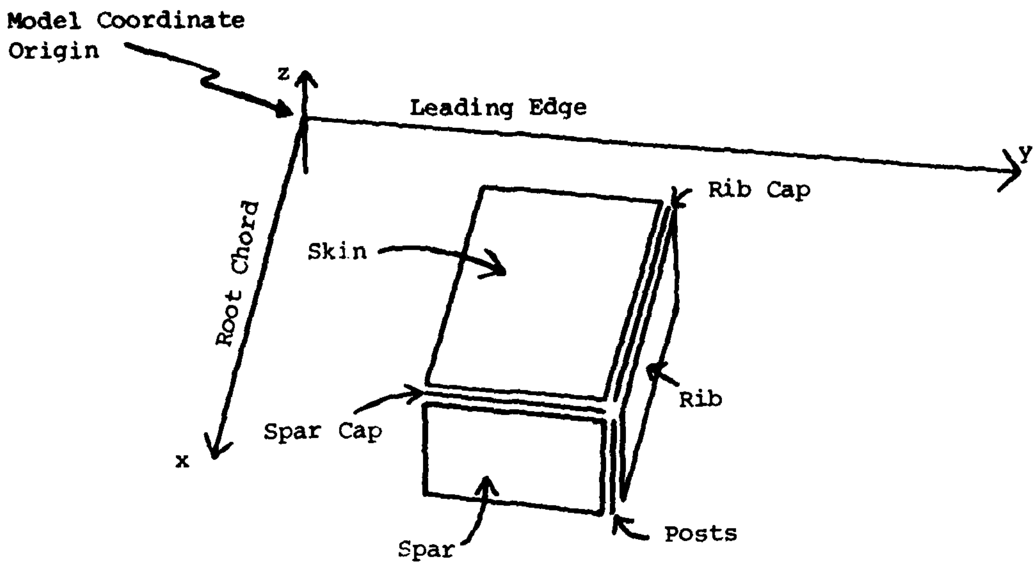
2.8 WINGEN - MODEL DEFINITION DATA FORMAT

The following section describes the Batch mode or Semi-interactive mode card input data for the WINGEN wing model preprocessor program. The definition procedure for the wing can be broken down into 12 sections as follows:

1. problem title
2. wing profile definition
3. planform description
4. wing depth description
5. wing skin properties definition
6. ribs definition
7. spars definition
8. modify directives
9. posts definition
10. refinement directives
11. damage specifications
12. loads definition

For each item of input a corresponding FORTRAN variable name is listed. Unless otherwise noted, the type of the input variable corresponds to the standard FORTRAN naming conventions (names beginning with the letters I - N are integer; all others are floating point numbers). All floating point data may be input with or without exponents in the data field provided. Integers and exponents must be right-justified in the data field. The terms utilized extensively in this section are illustrated in Figure 2.8.1 and a glossary is provided to assist the user with term definition.

The user must include one card for each of the twelve categories as explained below in each section. When the file is completed the user should save it as a permanent disk file and attach it as TAPE4 for use with Batch or Semi-interactive WINGEN execution modes. This section also describes the data required for full interactive execution of WINGEN. In this case the program will prompt the user for the appropriate data.



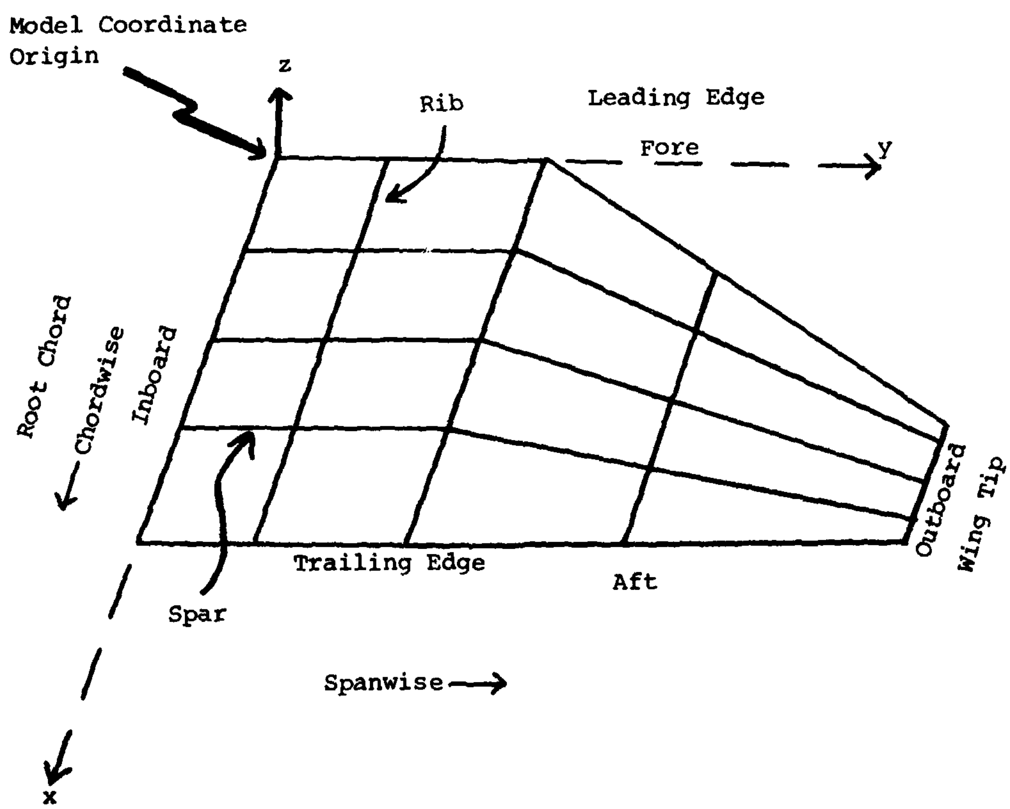


Figure 2.8.1. Illustrated here are the components and terminology for model development in this report.

2.8.1 Problem Title

(required)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-80	TITLE	Alphanumeric problem title	1

NOTES:

(1) This title is utilized in the postprocessor program CONTOUR for labeling the plot and as a header on all pages of the MAGNA analysis run and WINGEN output listing.

2.8.2 Wing Profile Parameters

(required)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-7	PROFILE	Literal 'PROFILE'	-
	8		(blank)	-
	9-10	NP	Planform shape code literal: 'P1' = rectangular 'P2' = full swept 'P3' = piecewise linear 'P4' = general	1
	11		(blank)	
	12-13	NC	Chordwise depth distribution code literal: 'C1' = constant chord depth 'C2' = linear chord depth 'C3' = piecewise linear chord depth 'C4' = general	2
	14		(blank)	
	15-16	NS	Spanwise depth distribution code literal: 'S1' = constant depth span 'S2' = linear depth span 'S3' = piecewise linear depth span 'S4' = general	3

NOTES:

(1) Diagramed in Figure 2.8.2 are the three program-defined planform shapes corresponding to P1, P2 and P3. P4 is a general class and should only be used with chord and spanwise depth distributions C4 and S4.

(2) The three program-defined chordwise depth distributions for C1 - C3 codes are illustrated in Figure 2.8.3. Chordwise depth code C4 is a general class and should only be used with planform and spanwise codes P4 and S4.

(3) The three program-defined spanwise depth distributions for S1 - S3 codes are illustrated in Figure 2.8.4. Spanwise depth code S4 should only be used in conjunction with planform and chordwise depth codes P4 and C4.

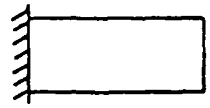
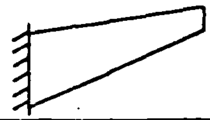
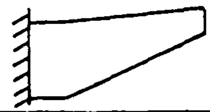
PROFILE	CONFIGURATION CODE	DESCRIPTION	SKETCH
	P 1	RECTANGULAR	
PLANFORM	P 2	FULL SWEPT	
	P 3	PIECEWISE SWEPT	

Figure 2.8.2. Three Planform Classes.

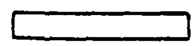
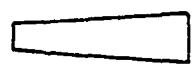
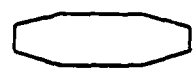
PROFILE	CONFIGURATION CODE	DESCRIPTION	SKETCH
	C 1	CONSTANT DEPTH	
CHORDWISE	C 2	LINEAR DEPTH	
	C 3	PIECEWISE LINEAR DEPTH	

Figure 2.8.3. Three Chordwise Depth Classes.

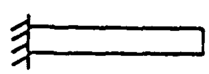
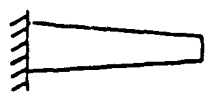
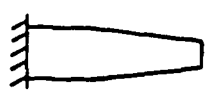
PROFILE	CONFIGURATION CODE	DESCRIPTION	SKETCH
	S 1	CONSTANT DEPTH	
SPANWISE	S 2	LINEAR DEPTH	
	S 3	PIECEWISE LINEAR DEPTH	

Figure 2.8.4. Three Spanwise Depth Classes.

2.8.3 <u>Planform Description</u>

(required)

A. Profile Type Pl

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-4	PLAN	Literal 'PLAN'	-
	5		(blank)	-
	6-15	ROOTC	Root chord dimension	1
	16-25	SPAND	Span dimension	2

NOTES:

(1) The root chord dimension is measured from fore to aft (leading edge to trailing edge of wing) along the root edge of the wing, as illustrated in Figure 2.8.5.

(2) The span dimension is the distance from the wing root to the wing tip measured perpendicular to the root chord. This is illustrated in Figure 2.8.5.

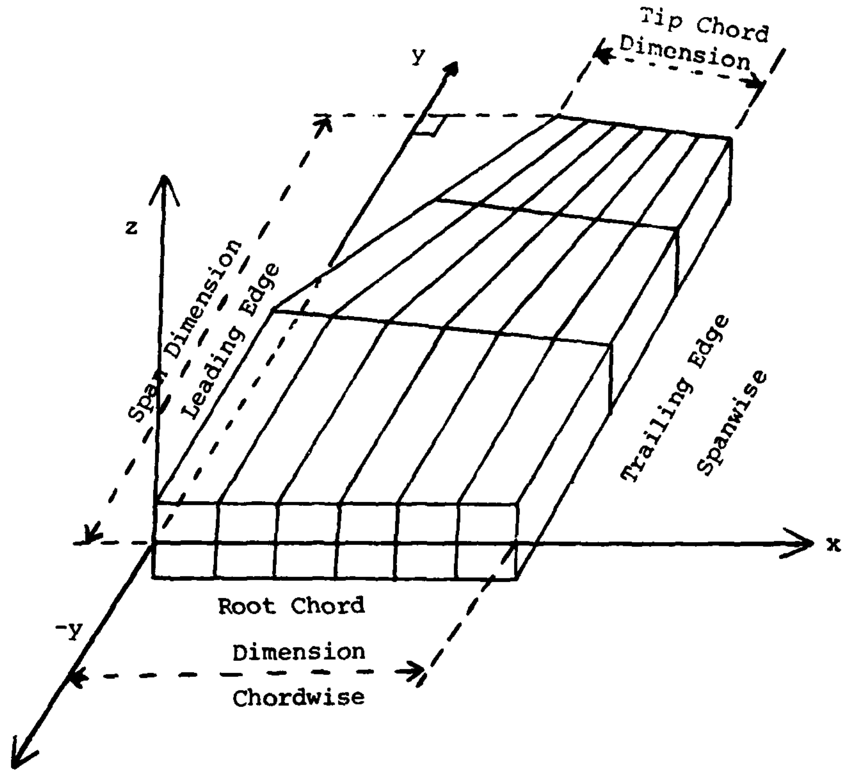


Figure 2.8.5. Root chord dimension and span dimension.

B. Profile Type P2

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-4 5	PLAN	Literal 'PLAN' (blank)	-
	6-15 16-25	ROOTC SPAND	Root chord dimension Span dimension	1 2
	26-35	TIPC	Tip chord dimension	3
	36-45	SWEEP	Leading edge sweep angle (degrees)	4

NOTES:

(1) The root chord dimension is measured from fore to aft (leading edge to trailing edge) along the root edge of the wing, as illustrated in Figure 2.8.5.

(2) The span dimension is the distance from the wing root to the wing tip measured perpendicular to the root chord. This is illustrated in Figure 2.8.5.

(3) The tip chord dimension is measured from fore to aft (leading edge to trailing edge) along the tip edge of the wing. This is illustrated in Figure 2.8.5.

(4) The leading edge sweep angle is the angle in degrees that the leading edge of the wing deviates from the perpendicular intersection of the root chord. This is illustrated in Figure 2.8.6.

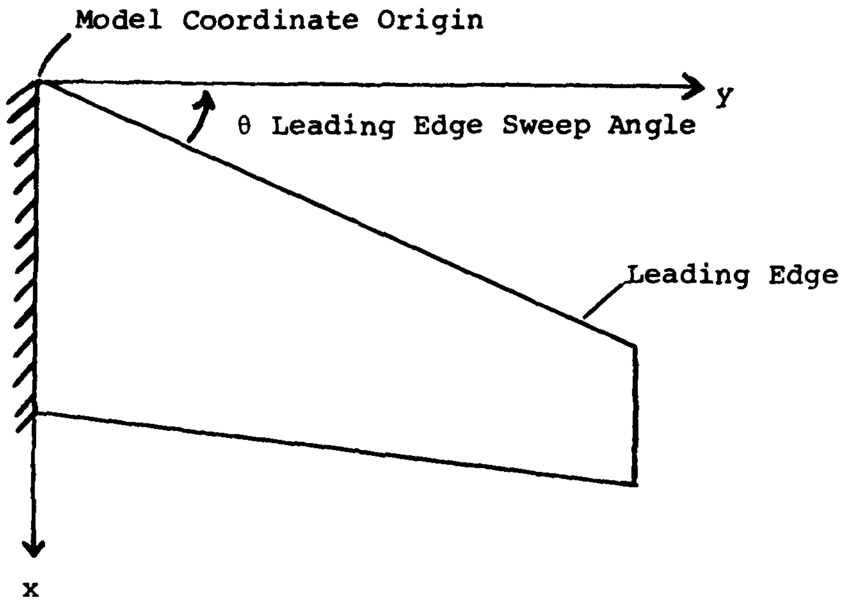


Figure 2.8.6. The leading edge sweep angle is the angle, in degrees, that the leading edge of the wing deviates from the horizontal y-axis.

C. Profile type P3

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-4	PLAN	Literal 'PLAN'	-
	5		(blank)	
	6-10	NSEGS	Number of spanwise stations to be used in defining planform shape	1
2	1-10	XLE	Leading edge x-coordinate	2
	11-20	YLE	Leading edge y-coordinate	2
	21-30	XTE	Trailing edge x-coordinate	2
	31-40	YTE	Trailing edge y-coordinate	2

NOTES:

(1) A spanwise station is defined for this program as being the point where two wing sections with differing sweep angles intersect. For N spanwise sections there must be N+1 spanwise stations defined as illustrated in Figure 2.8.7.

(2) Each spanwise section is to be defined beginning at the leading edge root segment and moving outboard. Repeat card 2 NSEGS times to define all spanwise segments. The origin of coordinates is the leading edge root point; x is measured positive aft and y is measured positive outboard.

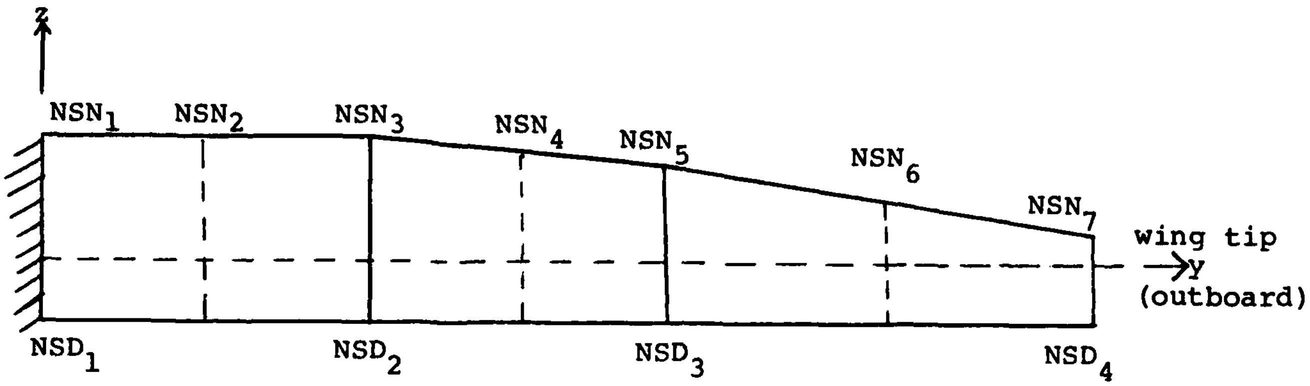


Figure 2.8.7. A new spanwise depth station must be defined for each change in wing thickness. This model has four depth stations defined (NSD_1-NSD_4). For comparison the seven spanwise nodal stations are also labeled (NSN_1-NSN_7), one for each rib in the model.

D. Profile type P4

This section defines the Direct Nodal Point Input for the general class of wings designated as P4-C4-S4 in the planform definition.

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-5	NSD	Number of spanwise nodal stations to be input	1
	6-10	NODES	Total number of nodal points	2
	11-15	ISW	Number of pairs of nodal coordinates to be switches	3
	16-20	ISW1(1)	Index of 1st coordinate in 1st pair switched	4
	21-25	ISW2(1)	Index of 2nd coordinate in 1st pair switched	4
	26-30	ISW1(2)	Index of 1st coordinate in 2nd pair switched	4
	31-35	ISW2(2)	Index of 2nd coordinate in 2nd pair switched	4
	36-40	ISW1(3)	Index of 1st coordinate in 3rd pair switched	4
	41-45	ISW2(3)	Index of 2nd coordinate in 3rd pair switched	4
2	1-10	FACT(1)	Scale factor for (switched) x-coordinate	5
	11-20	FACT(2)	Scale factor for (switched) y-coordinate	5
	21-30	FACT(3)	Scale factor for (switched) z-coordinate	5
3	1-80	FORMAT	FORMAT (including parenthesis) for nodal coordinate input to follow	6
4	1-5	NL(1)	Spanwise nodal stations input	7
	6-10	NL(2)	up to 16 per card	
	11-15	NL(3)		
	⋮	⋮		
	76-80	NL(16)		

CARD	COLUMN	DATA	DESCRIPTION	NOTES
5		NODE	Node number	8
		X	x-coordinate of node	8
		Y	y-coordinate of node	8
		Z	z-coordinate of node	8

NOTES:

(1) NSD must be greater than 0. This parameter defines the number of spanwise nodal stations to be input on card 4. A spanwise nodal station required for this input is the last node defined for each row of nodes located between the leading and trailing edges (spanwise). This is illustrated in Figure 2.8.8 where A, B, C, D, E and F denote spanwise nodal stations.

(2) The P4-C4-S4 planform type requires the user to input all nodes to WINGEN in x-, y- and z-coordinate form. NODES is the total number of nodes required to define the model. The program will request format specifications on card 3 for input of NODES nodal points from card 5.

(3) A special option for translating nodal coordinates from one axis to another (e.g., from x to y or z to x and vice versa) is provided. This is for the case where a previously defined model perhaps developed for an alternative analysis program is being input for analysis by MAGNA. The switched nodal coordinates allow for the translation of the model in space so it will conform to the x, y, z coordinate axes established by this program where the wing model coordinate origin is at the junction of the leading edge, the root chord and centered at

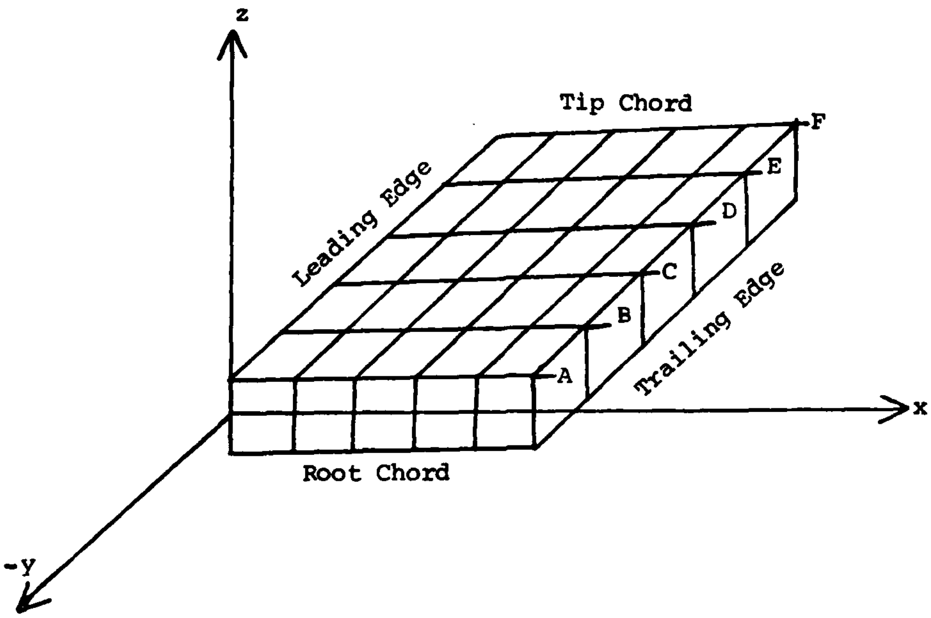


Figure 2.8.8. The six spanwise nodal stations of the replica wing specimen are labeled A-F.

the midpoint of the wing depth with the z-axis vertical, the x-axis extending chordwise, fore to aft, and the y-axis extending spanwise root to tip (outboard).

ISW is the number of coordinate groups to be switched where

0 = no coordinate transformations

1 = 1 pair of coordinate transformations

2 = 2 pair of coordinate transformations

3 = 3 pair of coordinate transformations.

The maximum number of transformations is 3.

(4) Coordinate transformations must be entered in pairs where 1 = x, 2 = y and 3 = z. The transformation should result in having x at 1 y at 2 and z at 3. For example, if data being input is as follows: node, z, x, y. Then two pairs of coordinate transformations are necessary:

1st pair of switches is 1 and 2 which leaves x in the 1st array position and z in the 2nd array position. 2nd pair of switches is 2 and 3 which leaves y in the 2nd array position and z in the 3rd array position.

The value range for ISW1 and ISW2 is from 1 to 3.

(5) FACT(1) - FACT(3) correspond to coordinate multipliers for altering the model origin of the nodes being input. All nodes will be multiplied by these factors therefore a factor of 1.0 must be specified for all three factors if no coordinate shifting is to take place. FACT(1), FACT(2) and FACT(3) represent the (transformed) x-, y- and z-coordinate multipliers, respectively.

(6) FORMAT must contain the entire format including parenthesis according to CDC FORMAT statement syntax. All data on card 5 will be input utilizing this format. Each read using FORMAT will look for NODE, X, Y, Z values.

(7) Repeat card 4 enough times to define NSD spanwise nodal stations (e.g., NSD/16 = # card 4 required). Each card 4 may have up to 16 nodal stations. See notes 1 for more information on spanwise nodal stations.

(8) Repeat card 5 until NODES nodes have been input. The format to input these values was defined on card 3. NODE should begin at 1 and increment sequentially by 1. The x-, y- and z-coordinates will all be multiplied by the appropriate FACT(1), FACT(2) or FACT(3) as defined on card 2.

2.8.4 Wing Depth Distribution

(omit for P4-C4-S4 profile type)

A. Constant Depth - for span type S1; chord type C1 only. (Refer to Figure 2.8.4.)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-5	DEPTH	Literal 'DEPTH'	-
	1-10	WDEPTH	Total wing depth	1

NOTES:

(1) This is for a wing with constant wing depth (thickness) throughout.

B. Chordwise Variation Only - for span type S1; chord types C2 and C3 only. (Refer to Figure 2.8.4.)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-5	DEPTH	Literal 'DEPTH'	-
	6-10		(blank)	-
	11-15	NCD	Number of chordwise stations at which depths will be specified	1
2	1-10	X	x-coordinate for depth stations	2
	11-20	WDEPTH	Wing depth at this station	3

NOTES:

(1) Repeat card 2 NCD times to define all chordwise depth stations. Begin at the leading edge and proceed to the trailing edge along the root chord to define NCD depth stations. There must be a minimum of 2 such stations specified. See figure 2.8.9.

(2) The x-coordinate requested is in the units system supplied by the user in defining the model.

(3) The wing depth should be measured from the top of the lower skin to the bottom of the upper skin for most accurate results.

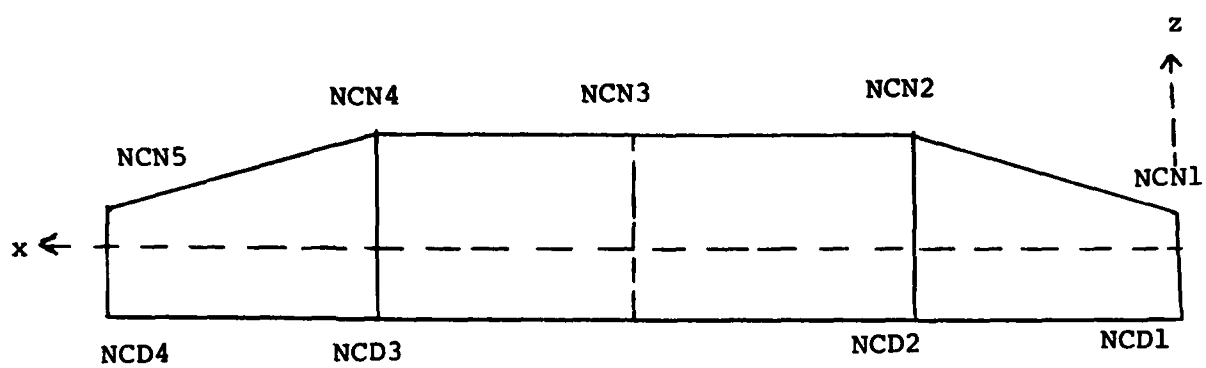


Figure 2.8.9. A new chordwise depth station must be defined for every change in wing thickness. This model has four depth stations defined (NCD_1-NCD_4) and for comparison five chordwise nodal stations (NCN_1-NCN_5); one for each spar defined in the model.

C. Spanwise Depth Variation - for span types S2 and S3; chord types C1, C2 and C3 only. (Refer to Figure 2.8.4.)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-5	DEPTH	Literal 'DEPTH'	-
	6-10	NSD	Number of spanwise depth stations for which data will be specified.	1
	11-15	NCD	Number of chordwise depth stations for which data will be specified	1
2	1-10	X	Depth station x coordinate	2
	11-20	Y	Depth station y coordinate	2
	21-30	WDEPTH	Wing depth at this coordinate	3

NOTES:

(1) Repeat card 2 for each NCD and NSD station to be defined; a total of NSD*NCD cards will be required. A spanwise depth station is that point where the depth of the wing changes as one travels from root to tip along the wing. A chordwise depth station is that point where the depth of the wing changes in moving from leading edge to trailing edge.

(2) The user should define the depths starting at the wing coordinate origin and moving along the root chord (fore to aft) then spanwise to the next depth station along the leading edge and working to the trailing edge, etc., until all depth stations have been defined.

(3) Wing depth is measured from the top of the lower skin to the bottom of the upper skin.

2.8.5 Wing Skin Properties

(required)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-4 5	SKIN	Literal 'SKIN' (blank)	-
	6-10	NMATU	Upper skin material property code	1
	11-15	NMATL	Lower skin material property code	1
	16-25	TUPPER	Upper skin thickness	2
	26-35	TLOWER	Lower skin thickness	2

NOTES:

(1) The program has 2 material property codes predefined:

	LINEAR AND NONLINEAR ANALYSIS	
	Material 1	Material 2
Material	aluminum	steel
Elastic Modulus lb/in^2	$.10*10^8$	$.30*10^8$
Poisson's Ratio	.30	.33
Mass Density lb sec^2/in^4	$.259*10^{-3}$	$.725*10^{-3}$
EQ Stress at 1st Yield lb/in^2	$.10*10^5$	$.30*10^5$
	NONLINEAR ANALYSIS ONLY	
Strain Hardening Curve	1	1
Uniaxial Stress/Strain Data Curve	2	2

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STRUCTURAL FLIGHT LOADS SIMULATION CAPABILITY. VOLUME II. STRUC--ETC(U)
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UNCLASSIFIED UDR-TR-80-73-VOL-2 AFWAL-TR-3118-VOL-2 NL

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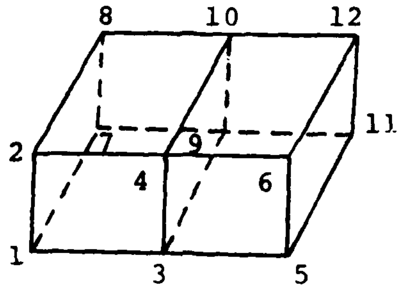
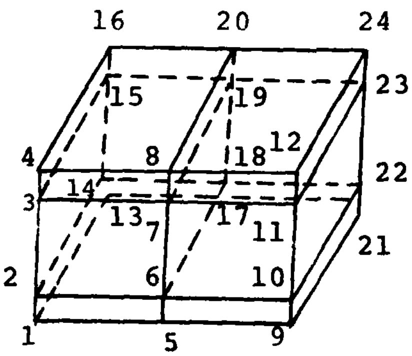
The user may select either one or add additional ones as required.

(2) Skin thicknesses should approximate as closely as possible the true skin thicknesses of the wing. If considerable variation exists alterations may have to be made to the WINGEN output file (TAPE11) prior to an analysis run. Note that in the generation of shell elements, the upper and lower skin thicknesses are utilized to generate new nodes in the z-direction at TUPPER and TLOWER displacements from the original nodes defining the membrane elements. The method of shell element generation is illustrated in Figure 2.8.10.



A

skin thickness = TUPPER



B skin thickness = TLOWER

Figure 2.8.10. Two chord bays of a span bay are used here to illustrate the thickness expansion for the upper and lower skin elements in converting from plate elements to shell elements. A) Nodes of basic model before shell element conversion B) Nodes of same elements after conversion to shell elements.

2.8.6 Rib Definition

(required)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-4	RIBS	Literal 'RIBS'	-
	5		(blank)	
	6-10	NRIB	Number of ribs to be defined	1
2	1-5	MAT	Material property code for rib	2
	6-10	MATC	Material property code for rib cap	2
	16-25	XI	Leading edge x-coordinate of rib	3
	26-35	YI	Leading edge y-coordinate of rib	3
	36-45	XO	Trailing edge x-coordinate of rib	3
	46-55	YO	Trailing edge y-coordinate of rib	3
3	1-10	RPROP(1)	Rib thickness	-
	11-20	RPROP(2)	Rib cap cross-sectional area	4

NOTES:

(1) Repeat cards 2 and 3 to define NRIB ribs. If NRIB = 0 or blank, card 1 completes this item.

(2) WINGEN predefines two material property codes as follows:

	LINEAR AND NONLINEAR ANALYSIS	
	Material 1	Material 2
Material	aluminum	steel
Elastic Modulus lb/in^2	$.10*10^8$	$.30*10^8$
Poisson's Ratio	.30	.33

Mass Density $lb\ sec^2/in^4$	$.259*10^{-3}$	$.725*10^{-3}$
EQ Stress at 1st Yield lb/in^2	$.10*10^5$	$.30*10^5$
	NONLINEAR ANALYSIS ONLY	
Strain Hardening Curve	1	1
Uniaxial Stress/Strain Data Curve	2	2

Additional codes may be added but the user must be careful to define these material property codes in the WINGEN output file (TAPE11) prior to executing an analysis. If MAT = 0 or blank no rib web is defined for the rib definition. If MATC = 0 or blank no rib caps are defined for the rib definition.

(3) Define each rib in terms of leading and trailing edge x-, and y-components; z-components will be supplied based on wing depth distributions. To define each rib begin with the rib closest to the wing coordinate origin and wing root and work from the wing root to the wing tip defining NRIB ribs as diagrammed in Figure 2.8.11.

(4) Each rib web will have associated with it an upper and lower rib cap if MATC > 0. The user must define the cross-sectional area of these rib caps (note: this is not a thickness parameter but a cross-section area value). This is illustrated in Figure 2.3.1.

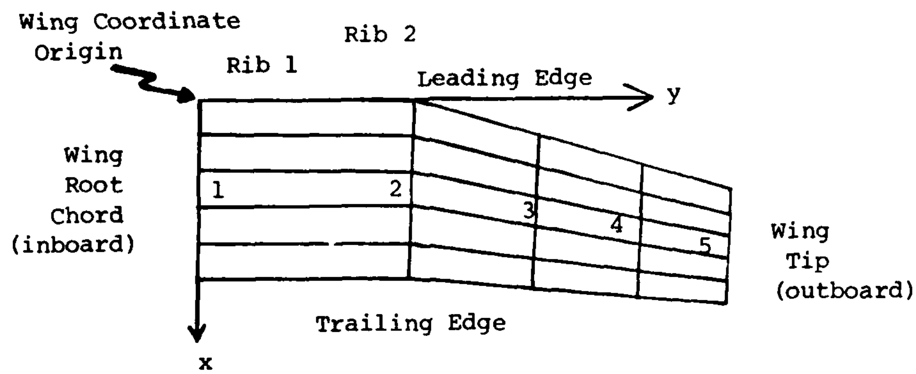


Figure 2.8.11. WINGEN will define five ribs for this model in the sequence indicated.

2.8.7 Spar Definition

(required)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-5	SPARS	Literal 'SPARS'	-
	6-10	NSPAR	Number of spars to be defined	1
2	1-5	MAT	Material property code for spar	2
	6-10	MATC	Material property code for spar cap	2
	16-25	XI	Inboard x-coordinate of spar	3
	26-35	YI	Inboard y-coordinate of spar	3
	36-45	XO	Outboard x-coordinate of spar	3
	46-55	YO	Outboard y-coordinate of spar	3
3	1-10	SPROP(1)	Spar thickness	-
	11-20	SPROP(2)	Spar cap cross-sectional area	4

NOTES:

(1) Repeat cards 2 and 3 until NSPAR spars have been defined. If NSPAR = 0 or blank card 1 completes this item.

(2) The program predefines two material property codes as follows:

	LINEAR AND NONLINEAR ANALYSIS	
	Material 1	Material 2
Material	aluminum	steel
Elastic Modulus lb/in^2	$.10*10^8$	$.30*10^8$

Poisson's Ratio	.30	.33
Mass Density lb sec^2/in^4	$.259*10^{-3}$	$.725*10^{-3}$
EQ Stress at 1st Yield lb/in^2	$.10*10^5$	$.30*10^5$
	NONLINEAR ANALYSIS ONLY	
Strain Hardening Curve	1	1
Uniaxial Stress/Strain Data Curve	2	2

The user may use these or may require additional ones. If codes other than 1 or 2 are used the user must take care to add these material properties to the WINGEN output file (TAPE11) prior to executing an analysis run.

If MAT = 0 or blank no spar webs will be defined for this spar. If MATC = 0 or blank no spar caps will be defined for this spar.

(3) Define each spar in terms of inboard and outboard x- and y-coordinates; the z-component is supplied by the program based on wing depth distribution. This is illustrated in Figure 2.8.12.

(4) Each spar web will have an associated spar cap if MATC > 0. The user must define the cross-sectional area of these caps. (Note: this is not a thickness parameter but a cross-section area value). This is illustrated in Figure 2.3.1.

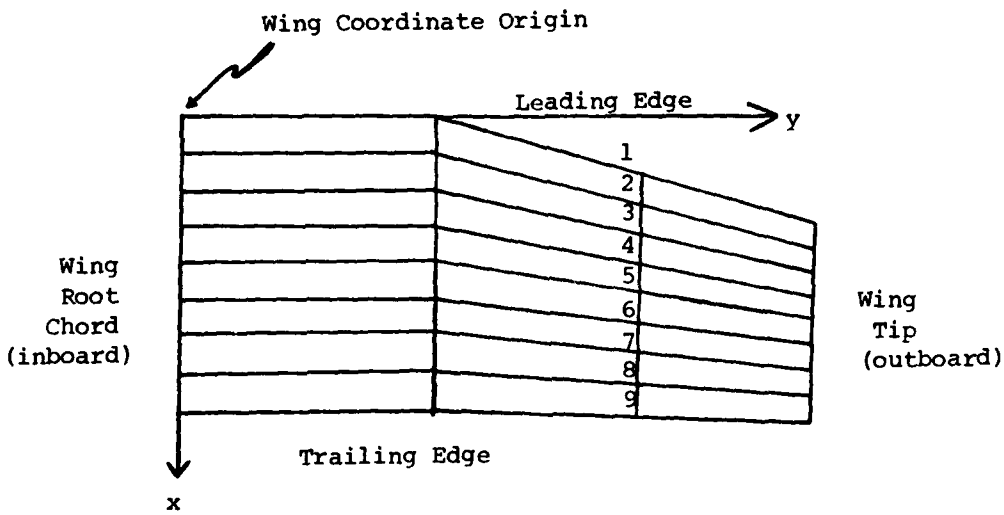


Figure 2.8.12. WINGEN will define nine spars for this model in the sequence indicated.

2.8.8 Modify Directives

(required)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-6	MODIFY	Literal 'MODIFY'	-
	7-10	ND	Number of modify data specifications	1

A. Class 1 - Removal of Selected Elements

CARD	COLUMN	DATA	DESCRIPTION	NOTES
2	1-7	ID	Modify type literal	2
	8-10		(blank)	
	11-15	INDXI	Spanwise bay of element to be removed	3
	16-20	INDXJ	Chordwise bay of element to be removed	3

B. Class 2 - Removal of Elements in a Specified Region

CARD	COLUMN	DATA	DESCRIPTION	NOTES
2	1-7	ID	Literal 'LOCATE' (modify type)	-
	8-20		(blank)	
	21-30	DX	x-coordinate of centroid of area to be removed	4
	31-40	DY	y-coordinate of centroid of area to be removed	4
	41-50	RAD	Spherical radius of area to be removed	4

NOTES:

(1) Repeat card 2 ND times to define all modifications to model. Classes 1 and 2 may be mixed freely. If ND = 0 or blank then card 1 completes this input item.

(2) There are eight designations for Class 1 modifications. These literals should be entered left justified. All Class 1 and Class 2 modifications should equal ND modifications. The designations for element removal are:

ID = SKINL - for lower skin element
SKINU - for upper skin element
RIB - for rib panel
RCAPL - for lower rib cap
RCAPU - for upper rib cap
SPAR - for spar panel
SCAPL - for lower spar cap
SCAPU - for upper spar cap

These may be entered in any combination or order to alter the model elements.

(3) Spanwise bays are numbered from root to tip; chordwise bays are numbered leading to trailing edges. For spars and spar caps, INDXI is the spanwise nodal line affected; for ribs and rib caps, INDXJ denotes the chordwise nodal line affected.

(4) DX and DY specify the center of a sphere of radius RAD. All elements whose centroids lie within this sphere will be removed. All values are given in model coordinates supplied by the user. It is assumed the user will generate an undamaged model first, then will generate a damaged model. DX, DY and RAD should be easily obtainable from the nodal coordinates data of the model.

2.8.9 Post Definition

(required)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-5	POSTS	Literal 'POSTS'	-
	6-10	NPST	Number of posts to be defined	1
2	1-5	IC	Chordwise station	2
	6-10	IS	Spanwise station	2
	11-15	MAT	Material property code for post	3
3	1-10	BPROP(1)	(blank)	
	11-20	BPROP(2)	Post cross-sectional area	4

NOTES:

(1) If NPST > 0, repeat cards 2 and 3 for each post to be defined in the model. If NPST < 0, insert only one of each card 2 and 3 leaving columns 1-10 blank on card 2. The program will generate a post at each rib-spar intersection with the given material properties. A note of caution: defining a model without posts will yield erroneous analysis results due to collapsing of the model under loading.

(2) The chordwise stations are defined from the wing coordinate origin located at the root chord (inboard) and leading edge (fore). To determine the appropriate chordwise station move aft (to trailing edge) along the root chord one station per defined chordwise depth station as defined in 2.8.4. Wing Depth Distribution. This is illustrated in Figure 2.8.13. It is best to define a post at the point of intersection of rib and spar and have it extend from the lower skin to the upper skin. The

spanwise stations are defined beginning at the wing coordinate origin and moving outboard (to the wing tip). Each spanwise depth station represents a spanwise station as illustrated below and defined in 2.8.4 Wing Depth Distribution. The parameters IC and IS effectively become a local coordinate system for defining where a post should be placed where IC is in the chordwise direction along the root chord and IS is in the spanwise direction along the leading edge.

(3) The program predefines two material property codes to be used for model definition:

	LINEAR AND NONLINEAR ANALYSIS	
	Material 1	Material 2
Material	aluminum	steel
Elastic Modulus lb/in^2	$.10*10^8$	$.30*10^8$
Mass Density lb sec^2/in^4	$.259*10^{-3}$	$.725*10^{-3}$
EQ Stress at 1st Yield lb/in^2	$.10*10^5$	$.30*10^5$
	NONLINEAR ANALYSIS ONLY	
Strain Hardening Curve	1	1
Uniaxial Stress/Strain Data Curve	2	2

Additional codes may be entered for preprocessor generation but the user must be careful to define any additional codes he utilizes by adding the appropriate data to the WINGEN output file (TAPE11).

(4) The user must define a cross-sectional area for the posts. This area should be neither too small nor too large or abnormally large stresses and strains will develop. (An area of .001 - .1 should be considered).

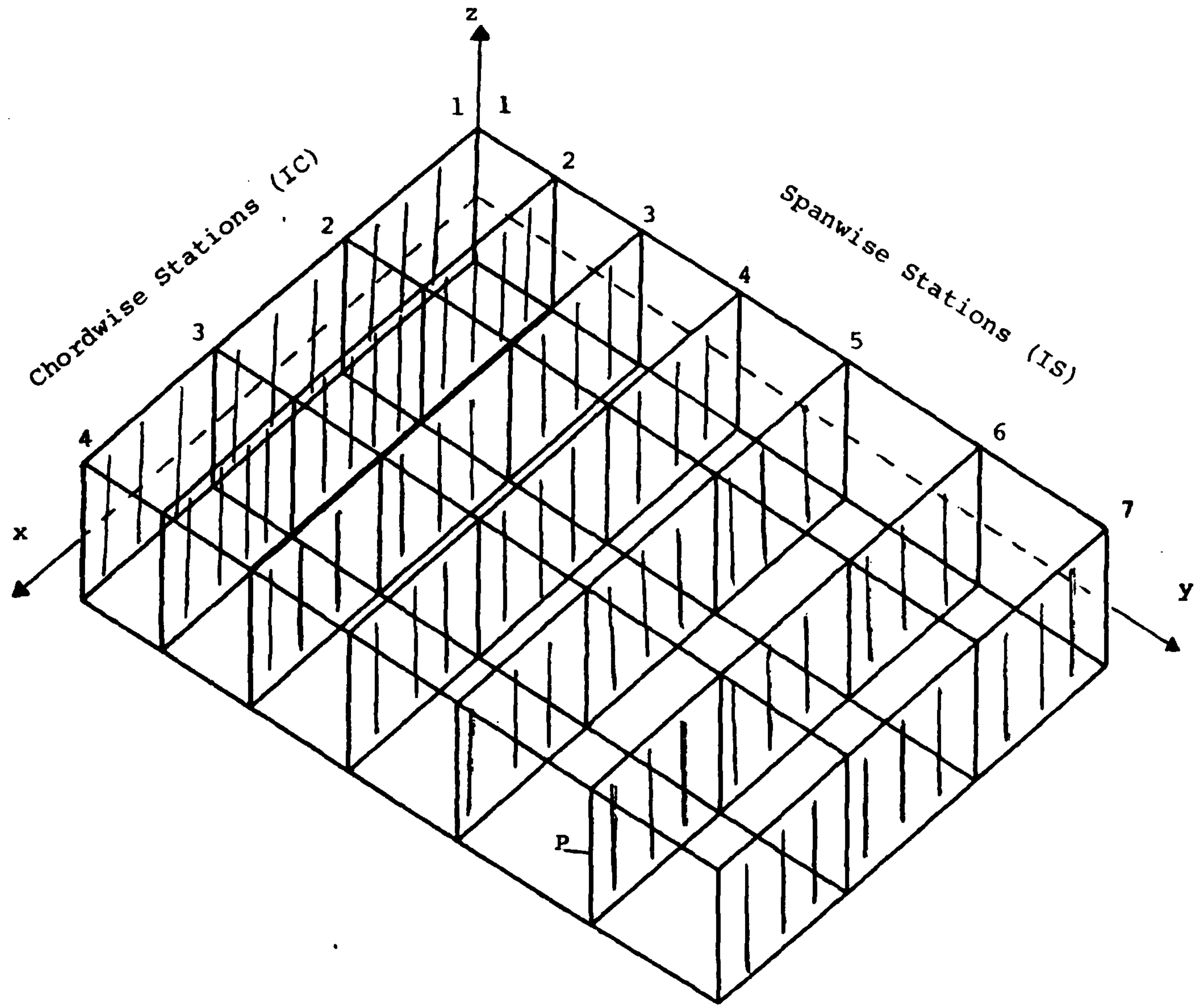


Figure 2.8.13. Illustration of chordwise and spanwise nodal stations. The designation to place a post at location P would be

IC = 4, IS = 6.

2.8.10 Refinement Directives

(required)

Any refinements made to the skins will result in meaningless analysis results unless the shell elements option is requested while executing WINGEN. See Section 2.3 WINGEN - MODEL DEFINITION for more information about this.

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-6	REFINE	Literal 'REFINE'	-
	7-10	NREF	Number of refinement data specifications	1
2	1-7	TYPE	Refinement type literal: 'SPAN' = spanwise refinement 'CHORD' = chordwise refinement 'THICK' = thickness (depth) refinement	2
	8-10		(blank)	-
	11-15	IDIV	Number of divisions	3
	16-20	IBAY	Bay number	4

NOTES:

(1) Repeat card 2 NREF times to define all refinement specifications. If NREF = 0 or is blank, no refinement is to be specified and card 1 completes this input item.

(2) Three refinement types are available:

'SPAN' results in a spanwise refinement
'CHORD' results in a chordwise refinement
'THICK' results in a depthwise refinement.

The repeated use of any one type in a single execution of WINGEN will yield additive results unless the IBAY option is utilized. Any number of each or all types may be input in any order. Figure 2.8.14 illustrates the three refinement types.

(3) IDIV represents the number of divisions each specified bay will be divided by. If IDIV = 1 each bay affected will be divided in half (one additional bay). If IDIV = 2 each bay affected will be divided into thirds (two additional bays).

(4) For IBAY = 0 or blank, all bays in the refinement type will be increased by IDIV divisions. If IBAY > 0 only the IBAY in the refinement type will be increased by the number of divisions.

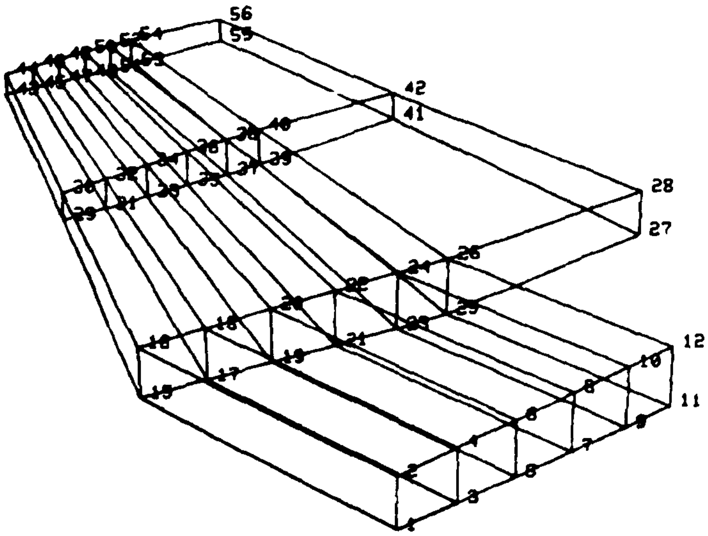


Figure 2.8.14a. T-38 wing model. No refinements specified for plot. All nodes are labeled.

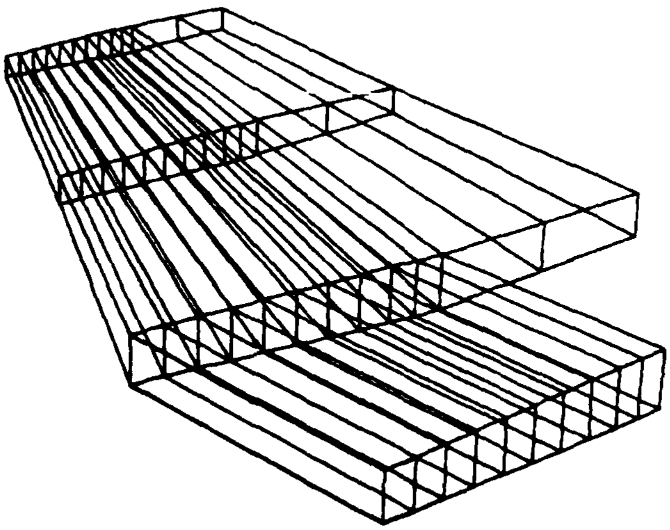


Figure 2.8.14b. T-38 wing model with CHORD refinement of 1 division.

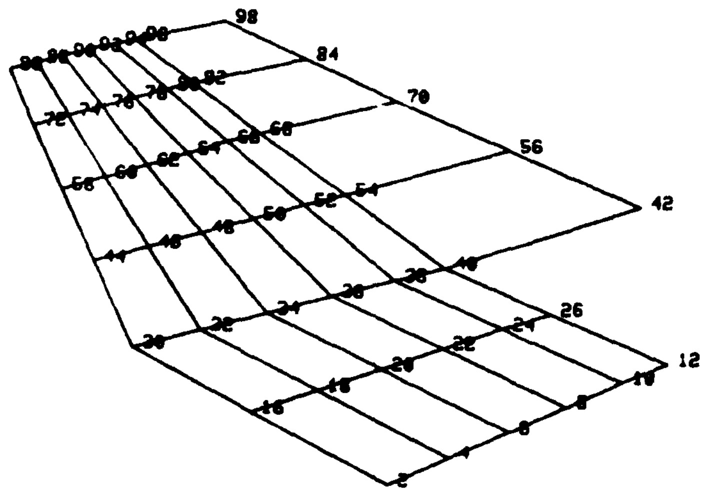


Figure 2.8.14c. T-38 wing model with SPAN refinement of 1 division. Plot of upper skin only and nodes labeled.

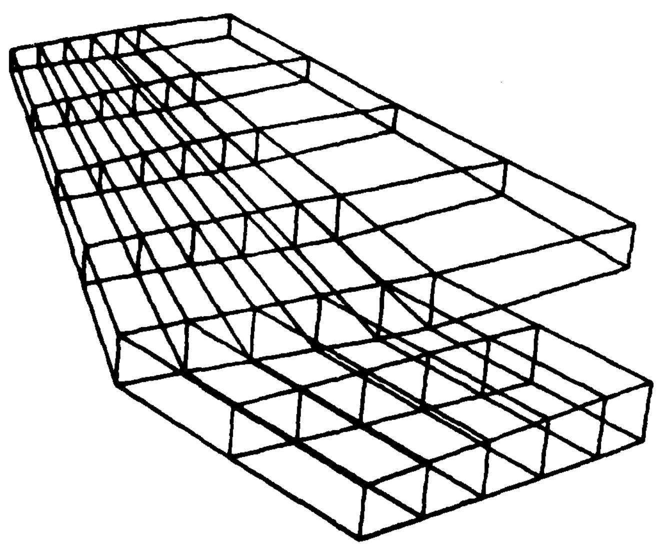


Figure 2.8.14d. T-38 wing model plot of entire wing with SPAN refinement.

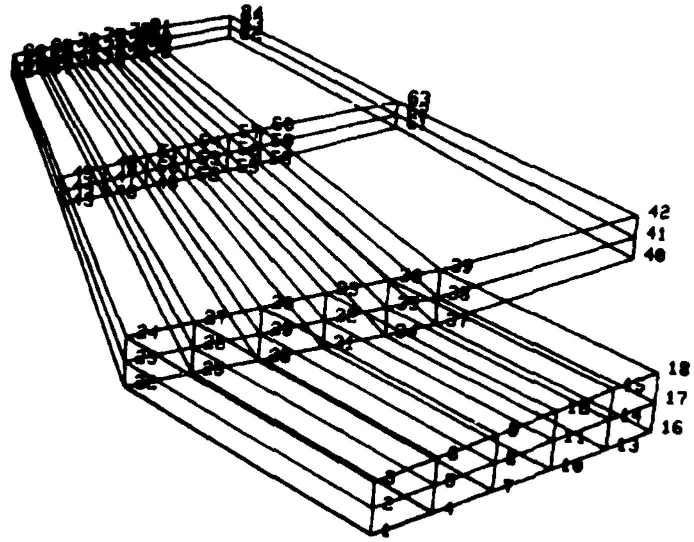


Figure 2.8.14e. T-38 wing model with THICK refinement of 1 division and nodes labeled.

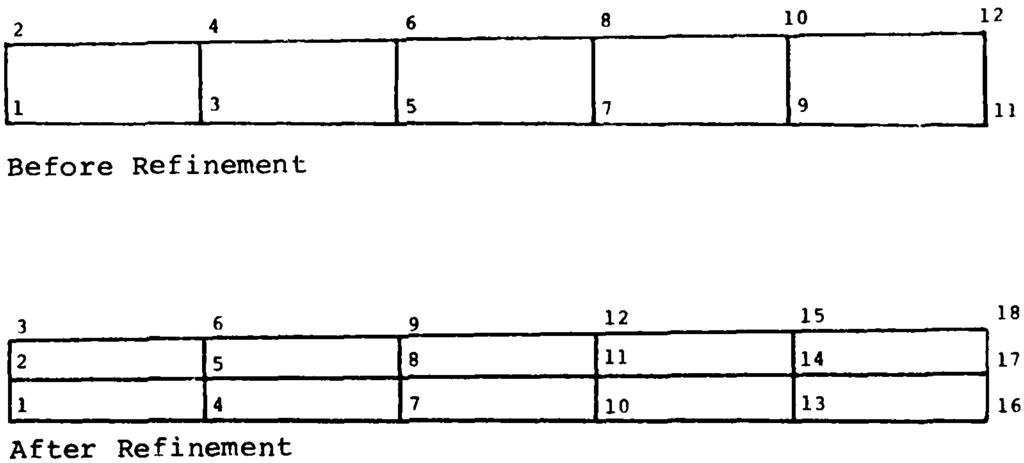


Figure 2.8.14f. T-38 wing model root chord elements before and after THICK refinement with nodes labeled.

2.8.11 Damage Specifications

(required)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-6	DAMAGE	Literal 'DAMAGE'	-
	7-10	ND	Number of damage data specifications	1

A. Class 1 - Deletion of Selected Elements

CARD	COLUMN	DATA	DESCRIPTION	NOTES
2	1-7	ID	Damage type literal	2
	8-10		(blank)	-
	11-15	INDXI	Spanwise bay of element to be deleted	3
	16-20	INDXJ	Chordwise bay of element to be deleted	3

B. Class 2 - Deletion of Elements in a Specified Region

CARD	COLUMN	DATA	DESCRIPTION	NOTES
2	1-7	ID	Literal 'LOCATE' (damage type)	-
	8-20		(blank)	
	21-30	DX	x-coordinate of centroid of area to be deleted	4
	31-40	DY	y-coordinate of centroid of area to be deleted	4
	41-50	RAD	Spherical radius of area to be deleted	4

NOTES:

(1) Repeat card 2 ND times to define all damages to model. Classes 1 and 2 may be mixed freely. If ND = 0 or blank, then card 1 completes this input item.

(2) There are eight designations for Class 1 damages. These literals should be entered left justified. All Class 1 plus Class 2 deletions should equal ND damage specifications. The designations for element deletions are:

ID = SKINL - for lower skin element
SKINU - for upper skin element
RIB - for rib panel
RCAPU - for upper rib cap
RCAPL - for lower rib cap
SPAR - for spar panel
SCAPU - for upper spar cap
SCAPL - for lower spar cap

These may be entered in any combination or order to define the model damage.

(3) Spanwise bays are numbered from root to tip; chordwise bays are numbered leading to trailing edges. For spars and spar caps, INDXI is the spanwise nodal line affected. For ribs and rib caps, INDXJ is the chordwise nodal line affected.

(4) DX and DY specify the center of a sphere of radius RAD. All elements whose centroids lie within this sphere will be deleted. All values are given in model coordinates supplied by the user. It is assumed the user will generate an undamaged model first, then will wish to generate a damaged model. DX, DY and RAD should be easily obtainable from the nodal coordinates data of the model.

2.8.12 Loads Definition

(required)

CARD	COLUMN	DATA	DESCRIPTION	NOTES
1	1-6	LOADS	Literal 'LOADS'	-
	7-10	NREF	Number of load data specifications	1
2	1-6	CENTER	Literal 'CENTER'	-
	7-10	MREF	Change center of load plane flag	2
3	1-10	XC	x-coordinate of new center of load plane	3
	11-20	YC	y-coordinate of new center of load plane	3
	21-30	ZC	z-coordinate of new center of load plane	3

A. Class 1 - Fixture Loads - Specifying point loads to be applied.

CARD	COLUMN	DATA	DESCRIPTION	NOTES
4	1-7	TYPE	Literal 'FIXTURE'	-
	8-10		(blank)	
	11-15	NLODS	Number of loads	4
5	1-10	F1	x-direction load value	5
	11-20	F2	y-direction load value	5
	21-30	F3	z-direction load value	5
	31-40	R1	x distance from structure centroid to applied load	6
	41-50	R2	y distance from structure centroid to applied load	6
	51-60	R3	z distance from structure centroid to applied load	6

B. Class 2 - Test Loads - Specifying loads to be distributed across all nodes on the loaded plane.

CARD	COLUMN	DATA	DESCRIPTION	NOTES
4	1-4	TYPE	Literal 'TEST'	-
	5-10		(blank)	
	11-15	ALPHA	Angle (degrees) of sweep of wing	7
5	1-10	F1	x-direction load on loaded plane	8
	11-20	F2	y-direction load on loaded plane	8
	21-30	F3	z-direction load on loaded plane	8
	31-40	F4	moment about x-direction of loaded plane	8
	41-50	F5	moment about y-direction of loaded plane	8
	51-60	F6	moment about z-direction of loaded plane	8

NOTES:

(1) Repeat cards 4 and 5 until NREF sets of load data have been input. If NREF = 0 or blank, no load is to be specified and card 1 completes this item.

(2) To change the center of the loaded plane from that which is calculated by the program at MREF > 0. If MREF > 0 the program will input card 3 and establish the center of the loaded plane as XC, YC, ZC. If MREF = 0 or blank, no change is desired and card 3 is omitted.

(3) The coordinates XC, YC, ZC specify the new center of the load plane. It is advisable to have the new center lie within the plane of loaded nodes. The effect of this command will be to alter the load axis of the wing. This is further illustrated in Figure 2.8.15. Default is to use the geometric center of the wing tip load plane.

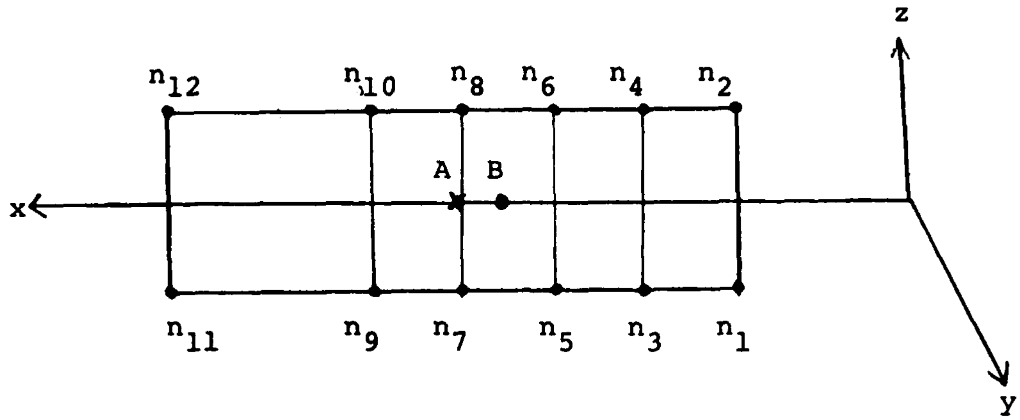


Figure 2.8.15. Illustration of the loaded plane of wing tip. 12 nodes (n_1-n_{12}) are shown and points A and B. Point A is at the geometric center of the loaded plane. Point B is at the intersection of the load axis and the load plane. See Figure 2.8.16.

(4) NLODS represents the number of points at which a load will be applied. Repeat card 5 until NLODS load specifications have been input.

(5) Actual loads to be applied must be resolved into x-, y- and z-components as requested by parameters F1, F2 and F3 of card 5.

(6) The point at which the load is to be applied is defined as an x-, y- and z-displacement from the centroid of the structure. Card 5 must be repeated NLODS times to define all points and their load values.

(7) ALPHA is the sweep angle of the wing (in degrees) from the y-axis for purposes of identifying the proper x-, y- and z-components of the moment loads that can be applied. The sweep angle is the angle between the load axis of the wing and the y-horizontal as illustrated in Figure 2.8.16.

(8) Two methods exist for introducing loads in the test case: 1) x-, y- or z-direction loads components and 2) x-, y- or z-direction moments of a loaded plane.

The loaded plane is defined as being all the wing tip nodes included in elements. The program will determine the center of this loaded plane unless the user overrides it with a 'CENTER' card. All moment loads will be resolved to the appropriate x-, y- and z-components and will be distributed across the load plane at each node based on the area that node encompasses such that there is a constant load distribution throughout the wing tip. This is further explained in Section 2.11.1.

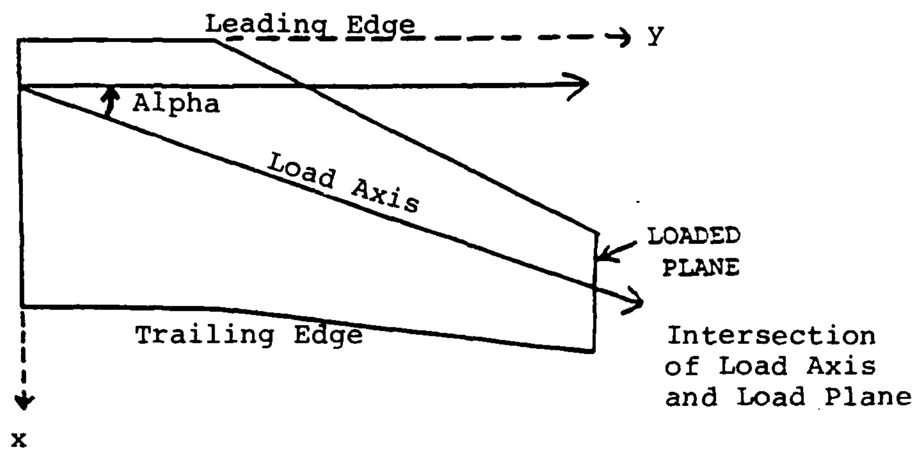


Figure 2.8.16. Alpha is the angle of intersection of the load axis with the y axis. This angle is used to determine correct moments of loads applied about the center of the loaded plane. Also see Figure 2.8.15.

2.9 MAGNA LOAD DECK CREATION

The primary purpose of the preprocessor WINGEN is the generation of nodes, element connectivities and all other pertinent data for the creation of a card deck (or card-image deck) which will be acceptable input to the finite element model analysis program MAGNA. This section discusses the third phase of the WINGEN operation process: the creation of the actual load deck data file once the model has been fully defined and all damages included. The user may request that thin-shell elements be utilized on the upper and lower skins to allow for analysis of a refined or damaged model. WINGEN reformats the data contained on the load deck data file to allow for the new elements and nodes. If the user responds to the program control directives that he wishes to use shell elements, the program will automatically generate a load deck. All the information necessary for a MAGNA analysis execution is contained in the load deck which is on file TAPE11 at the conclusion of the WINGEN execution. This file may be made permanent and attached later to be batched to input for a MAGNA analysis. Refer to Chapter 3 for details on performing a MAGNA analysis.

2.9.1 Load Deck Creation

Upon completion of the model generation WINGEN prompts the user for answers to several questions concerning load deck creation. A sample of these questions is included in Figure 2.9.1. The user should familiarize himself with the parameters requested concerning the actual analysis by MAGNA. Reference 1 contains full explanations of all MAGNA input data. Each question prompted by WINGEN will be explained below.

ENTER JOB CARD ID.....:

This question requests the user's computer ID symbol, a four character alphanumeric symbol for identifying computer generated

```
ENTER JOB CARD ID.......................: UDGK
ENTER JOB CARD COMMENT
(PROBLEM NO.,NAME,SYMBOL,ETC.).........: XXXXXXX,BRUNER,RI565.
MATERIAL NONLINEARITIES FLAG :
  1 -ELASTIC (LINEAR) ANALYSIS
  2 -PLASTIC (NONLINEAR) ANALYSIS
ENTER MATERIAL NONLINEARITIES FLAG.....: 1
GEOMETRIC NONLINEARITIES FLAG :
  1 -SMALL DISPLACEMENT (LINEAR) ANALYSIS
  2 -LARGE DISPLACEMENT (NONLINEAR) ANALYSIS
ENTER GEOMETRIC NONLINEARITIES FLAG....: 1
ENTER THE NUMBER OF LOAD STEPS TO BE
PERFORMED IN THE SOLUTION............: 1
ENTER LOAD INCREMENT STEP SIZE.........: 1
```

Figure 2.9.1. An example of Load Deck creation questions prompted by WINGEN upon generation of the model if the load deck option was selected.

output. This symbol is required because MAGNA must be run as a batch job.

```
ENTER JOB CARD COMMENT
(PROBLEM NO. NAME, SYMBOL, ETC.).....:
```

The problem number is the only item required here. A problem number is a six digit number preceded by a letter. This number is issued by the computing center for cost accounting purposes. Other information may also be of value including the individual's name and phone number in the event the output listing is sent to the wrong location.

```
MATERIAL NONLINEARITIES FLAG:
   1 - Elastic Analysis (linear)
   2 - Elastic-Plastic Analysis (nonlinear)
ENTER MATERIAL NONLINEARITIES FLAG.....:
```

The material nonlinearities flag selects whether the material is linear (Elastic Analysis) or nonlinear (Elastic-Plastic Analysis). Should the user select a nonlinear material flag, the large displacement analysis flag (geometric nonlinearities flag) will automatically be invoked by MAGNA.

```
GEOMETRIC NONLINEARITIES FLAG:
   1 - Small Displacement Analysis (linear)
   2 - Large Displacement Analysis (nonlinear)
ENTER GEOMETRIC NONLINEARITIES FLAG....:
```

The geometric nonlinearities flag should be set to small displacements analysis (1) for linear static analysis of elastic materials or set to large displacement analysis (2) for nonlinear static analysis of either elastic or plastic materials.

```
ENTER NUMBER OF LOAD STEPS TO
BE PERFORMED IN THE SOLUTION.....:
ENTER LOAD PARAMETER STEP SIZE...:
```

These two input items instruct the MAGNA program how to apply the designated loads to the model during analysis. The total loads specified will be divided by the number of load steps specified. The analysis will then occur adding a load value calculated to be one load step load (= total load/# steps) times the load parameter step size until the full load has been applied. The user will generally want both parameters equal to 1 for a linear analysis. A value of 20 load steps and a load parameter step size of 1 is usually adequate for a nonlinear analysis.

WINGEN will complete the load deck data file once the above questions have been answered. The load deck will be placed on local file TAPE11 at the conclusion of the WINGEN program execution. It is the user's responsibility to make this a permanent file for later access or to batch the file for punching out a card deck. Section 3.2 explains the load deck data file created and illustrates how alterations can be effected.

2.10 WINGEN PLOTTING CAPABILITIES

The ability to represent finite element models graphically has proved to be invaluable in model development and subsequent interpretation of model analysis results. WINGEN provides the model developer graphics capability for visual verification of the model being generated. The user has options for selecting the viewing position of the model, labeling nodes and/or elements, a limited zoom capability, orthogonal or perspective viewing, selected plotting of either type 3 elements or type 4 elements and plotting of x-, y- and z-axes. These features are necessary for adequate model verification by the user with the least amount of knowledge required to execute. Should the user require more comprehensive plotting capabilities (e.g. finer zoom, selected elements, expand elements, etc.) the PLOTBOB postprocessor plotting program can be utilized to view the input data to MAGNA which WINGEN places on TAPE11. Instructions for executing PLOTBOB are contained in Section 4.2.

To enable the graphics mode the user must respond 'Y' to the question in the program control directives:

GENERATE GRAPHS? (Y,N)......:

which is requested at the initiation of the program execution. Following the node and element connectivity generation will be questions concerning the load deck generation, if one was requested. The program will then enter the plotting phase and begins with the question:

ENTER THE CPS RATE.......:

to which the user responds with the characters per second transmission rate at which he is operating (usually either 30 cps or 120 cps). The program will request responses to several questions concerning eye position, minimum and maximum values and orthogonal or perspective viewing. The entire model will be displayed on the first plot but the user may select to plot only selected element types with or without labels on subsequent plots. Figures 2.10.1, 2.10.2 and 2.10.3 illustrate the various plotting commands available. These commands are described below.

2.10.1 Eye Position

WINGEN generates 3-D finite element models. To view a 3-D model the user must imagine the model in a 3-D space with the origin of the space at the model coordinates origin (see Figure 2.8.1). The user then specifies x-, y- and z-coordinates relative to the model origin to place his 'eye'. The program then scales all the data to display the model as though the viewer was actually at that relative distance. A useful initial viewing distance is (100,100,100) for most models.

2.10.2 Model Viewing

A model is represented as a 3-D object on a 2-D screen. Occasionally the user may wish to view only part of that object. The program will display the maximum and minimum x, y and z values of the model. The user may alter these and effectively move closer or farther away from the model. Utilizing the minima and maxima option the user can isolate any portion of the model he wishes and then alter the viewing angle for improved perspective. When altering the maxima and minima the user should input the values as MINX, MAXX, MINY, MAXY, MINZ, MAXZ. Only those nodes which lie within the selected range will be labelled. (See Figure 2.10.3).

2.10.3 Projection Type

Two projection types of view are available: orthogonal and perspective. An orthogonal view is one where the lines of the model are projected perpendicular to the viewing plane or screen. A perspective view occurs when the lines of the model are drawn so they intersect the viewing plane or screen while being drawn to the eye position. Figure 2.10.4 illustrates the two viewing types. The perspective view tends to distort the structure such that the elements closer to the eye appear larger than those farther away.

2.10.4 Axes

The user may wish to have x-, y- and z-axes drawn to help with the orientation of the model in space. The axes are drawn from the model coordinate origin to extend 10% beyond the maximum coordinate distance in each respective direction.

2.10.5 Node and Element Labels

Finite elements become very difficult to discriminate as models increase in size and complexity. It is useful, therefore, to be able to label the nodal points and elements to better ensure that the model has been properly generated. If the user selects to label the nodes, a node number will be written beside all nodes not outside the minima and maxima specified for the model. Plate (element type 3) and beam (element type 4) elements will also be labeled when requested if they do not occur outside the minima and maxima. For easier identification all plate element numbers are prefixed with a 'P' and all beam element numbers are prefixed with a 'B'. There is no prefix for the node numbers.

2.10.6 Selective Element Plotting

The user will generally desire to view only some part of the model in determining if it has been generated correctly. The program will allow the user the option of plotting all of the elements, just the plate elements (element type 3) or just the beam elements (element type 4). Should the user wish better element plotting selection it is suggested that he use PLOTBOB plotting program with the load deck file created on TAPE11. PLOTBOB program utilization is discussed in Section 4.2.

The user should be careful to enter the proper data for each of the plotting options above the first time as there is no means to reset the values before a plot is drawn. If wrong values are entered the user will have to allow the plot to be drawn then request another graph and set the parameters correctly the second time. Should the user request shell elements for the upper and lower skin he will need to utilize PLOTBOB to obtain a pre-analysis plot of the structure. WINGEN will generate plots of the structure prior to conversion to the shell elements so the user may utilize WINGEN plotting to verify that the model geometry is correct. The model will be converted following the plotting phase of WINGEN.

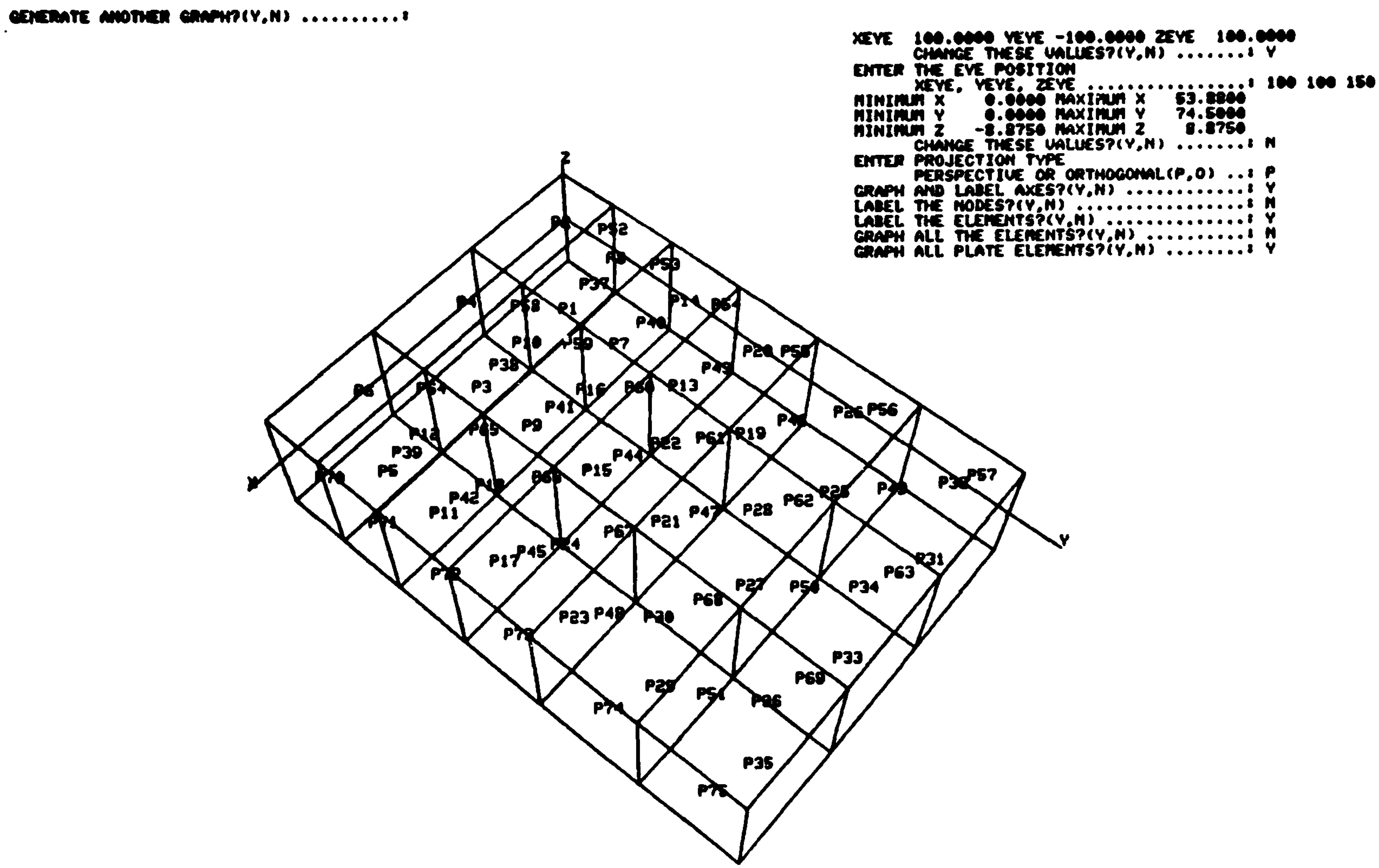


Figure 2.10.1. Sample plot from WINGEN plotting option. All plate elements are plotted and labeled (Type 3 element type). All options selected for this plot are listed in the upper right quadrant of this plot (this does not normally occur).

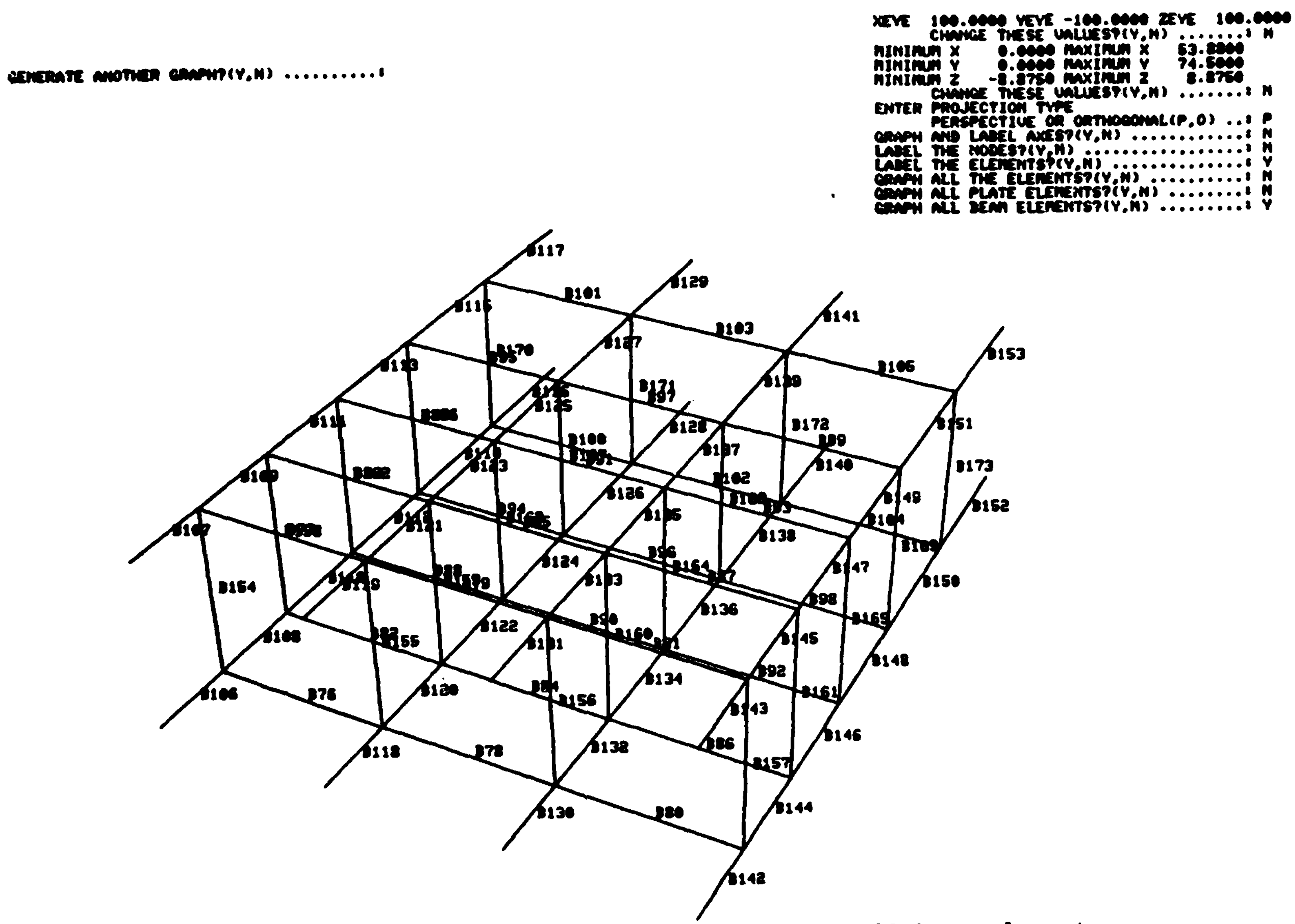


Figure 2.10.2. Sample plot from WINGEN plotting option. All beam elements are plotted and labeled (Type 4 elements or truss elements). All options selected for this plot are listed in the upper right quadrant of this plot.

```
GENERATE ANOTHER GRAPH?(Y,N) ..........:
```

```
XEYE  100.0000 YEYE  100.0000 ZEYE  150.0000
      CHANGE THESE VALUES?(Y,N) .......: N
MINIMUM X     0.0000 MAXIMUM X    53.8000
MINIMUM Y     0.0000 MAXIMUM Y    74.5000
MINIMUM Z    -8.8750 MAXIMUM Z     8.8750
      CHANGE THESE VALUES?(Y,N) .......: Y
ENTER THE MINIMA AND MAXIMA ...........: 0. 25.
0. 50. 0. 10.
ENTER PROJECTION TYPE
      PERSPECTIVE OR ORTHOGONAL(P,O) ..: P
GRAPH AND LABEL AXES?(Y,N) ............: Y
LABEL THE NODES?(Y,N) .................: Y
LABEL THE ELEMENTS?(Y,N) ..............: N
GRAPH ALL THE ELEMENTS?(Y,N) ..........: N
GRAPH ALL PLATE ELEMENTS?(Y,N) ........: N
GRAPH ALL BEAM ELEMENTS?(Y,N) .........: Y
```

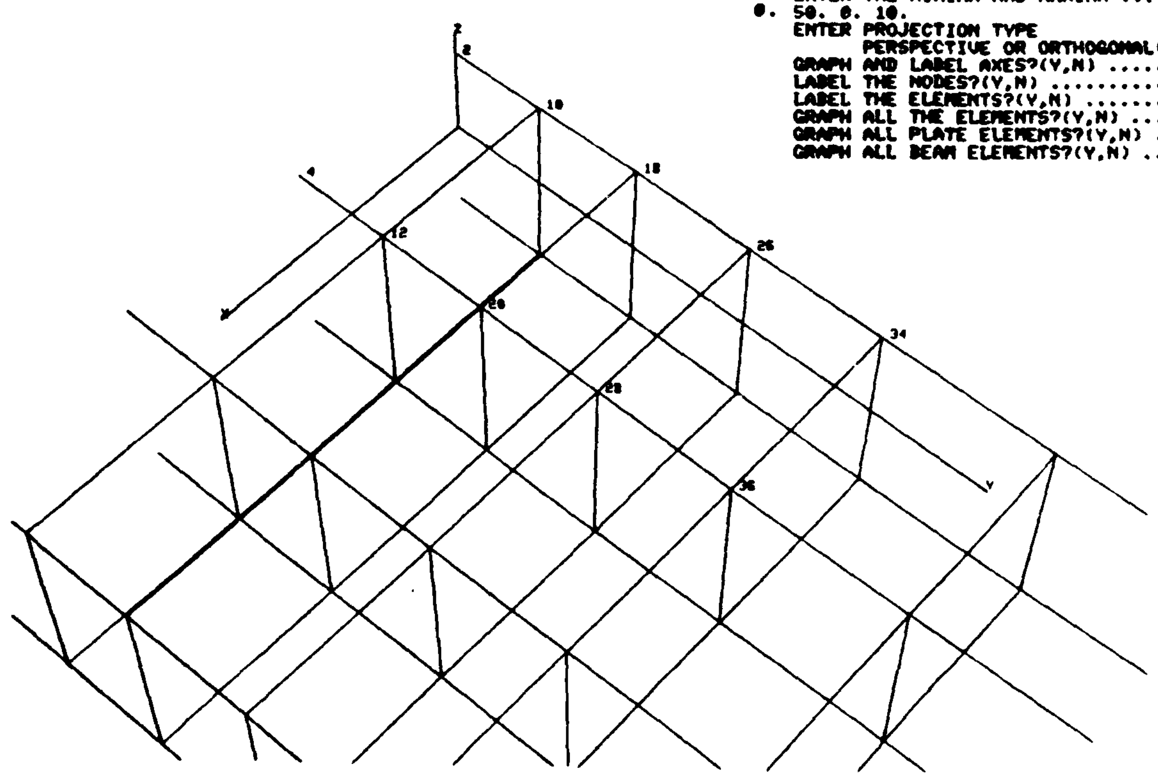


Figure 2.10.3. Sample plot from WINGEN plotting option. This is a 'ZOOM' plot of the structure illustrated in Figure 2.10.1. This is accomplished by altering the maxima and minima values of the plot.

GENERATE ANOTHER GRAPH?(Y,N) ....!

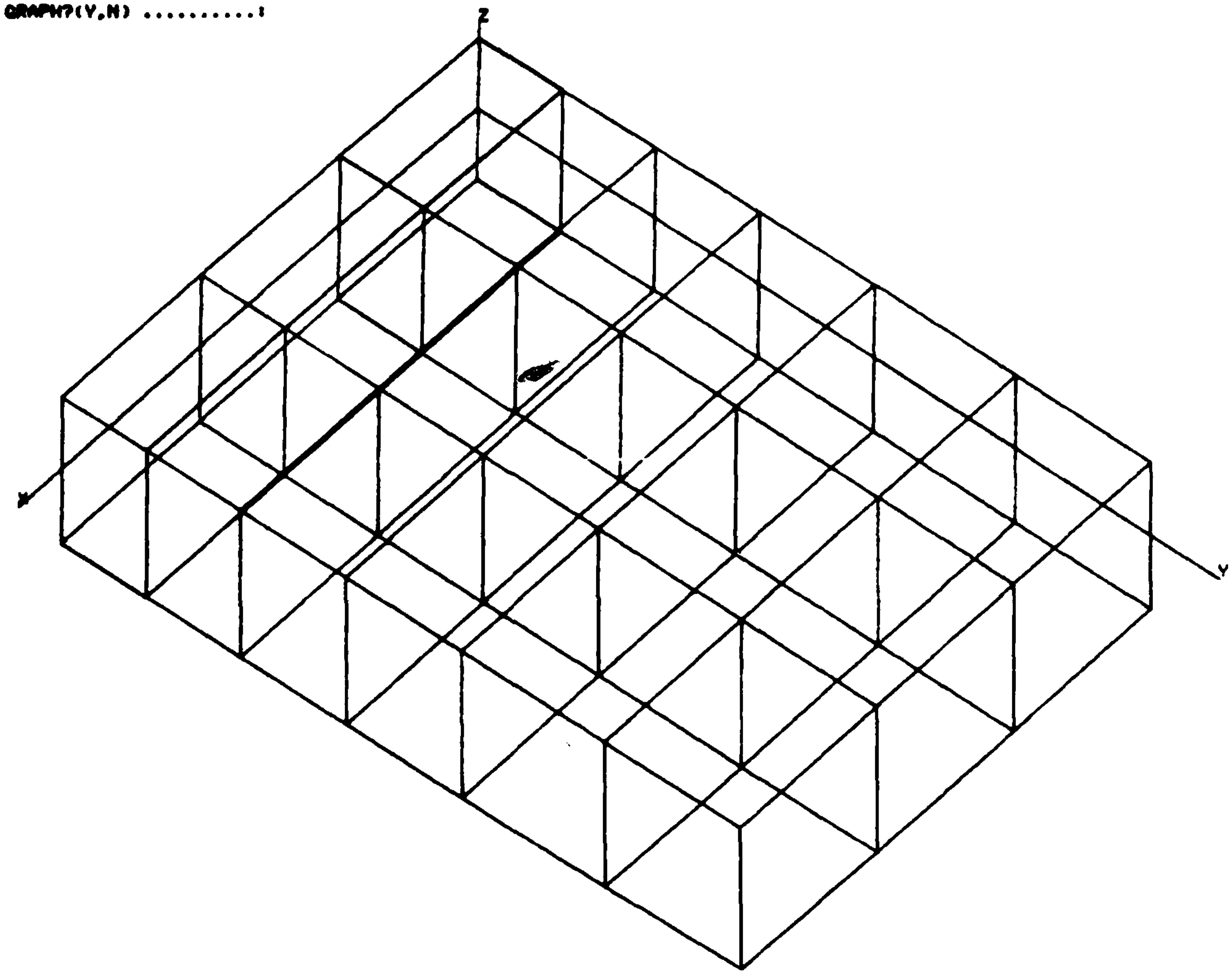


Figure 2.10.4a. Sample plot of replica wing structure with the orthogonal viewing option selected.

GENERATE ANOTHER GRAPH?(Y,N) ....!

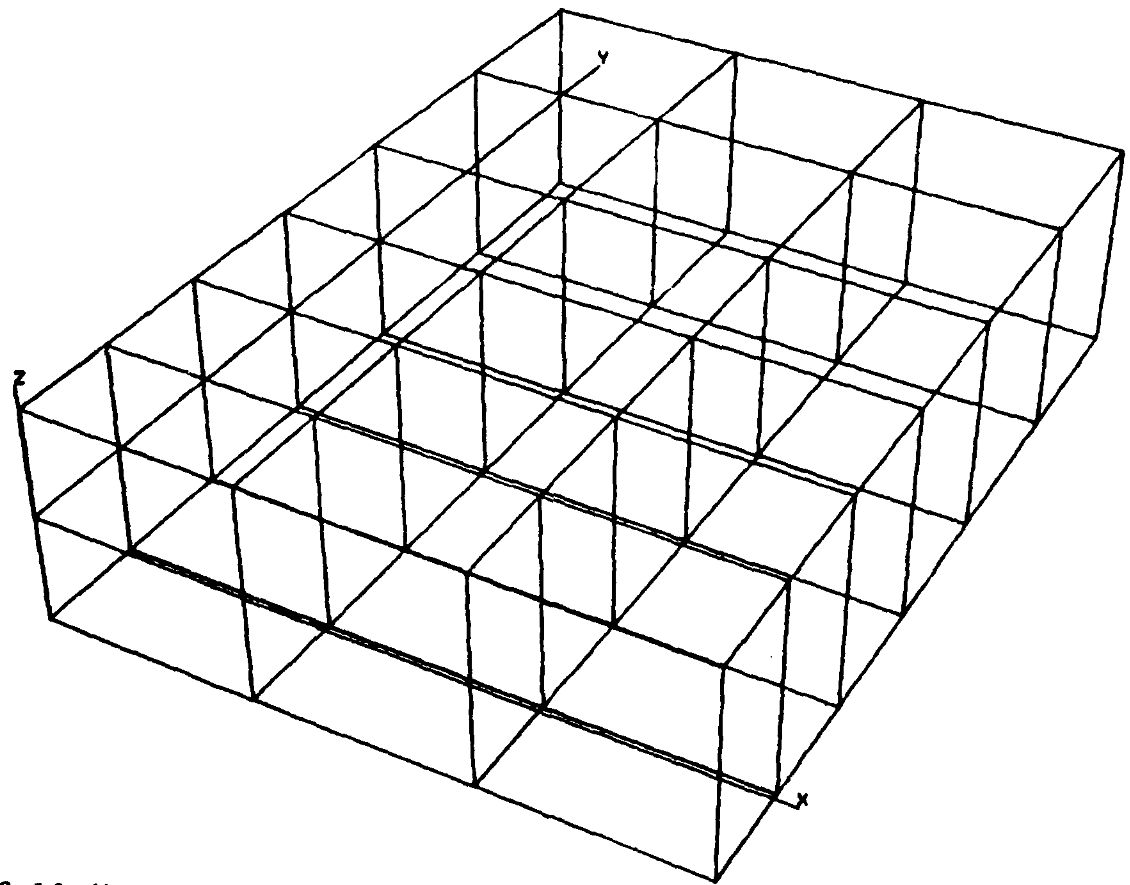


Figure 2.10.4b. Sample plot of replica wing structure with the perspective viewing option selected.

2.11 SPECIAL PROGRAM CONSIDERATIONS

Several areas of WINGEN processing provides the program user with time savings convenience for such areas of finite element modeling as refinement of the element mesh, generation of loads at the wing tip nodes and specification of damage conditions of the wing. Each of these program tools can be very useful to the user if their capabilities and limitations are fully understood. The remaining parts of this section will discuss each of these components in detail to allow the user full use of these features.

2.11.1 Loads Application

WINGEN provides the user with two methods of inputting loads to be distributed over the wing tip nodes. The nature of the loading situation in the experimental condition being simulated should determine the loading option selected by the user in the preprocessor. The 'TEST' option provided assumes the test specimen is attached to the test frame such that the only areas carrying the load are the skin thicknesses across the top and bottom wing skins. This option computes the area of the skin thickness associated with each node and distributes the load at each node as a proportion of the area encompassed by that node. The 'FIXTURE' option is provided for the situation where the load is distributed across the entire end area of the test specimen. This whole area is used to calculate the proportion of the load to be distributed at each node. Each of these options is discussed further below.

The process of applying loads to a simulated model must make assumptions to achieve some degree of realism. While the model being analyzed experimentally will experience a continuous distribution of loading across its loaded end a simulated model will only have loads applied at discrete points on a load plane. This situation is illustrated in Figure 2.11.1a and b where a is an experimental test frame generating

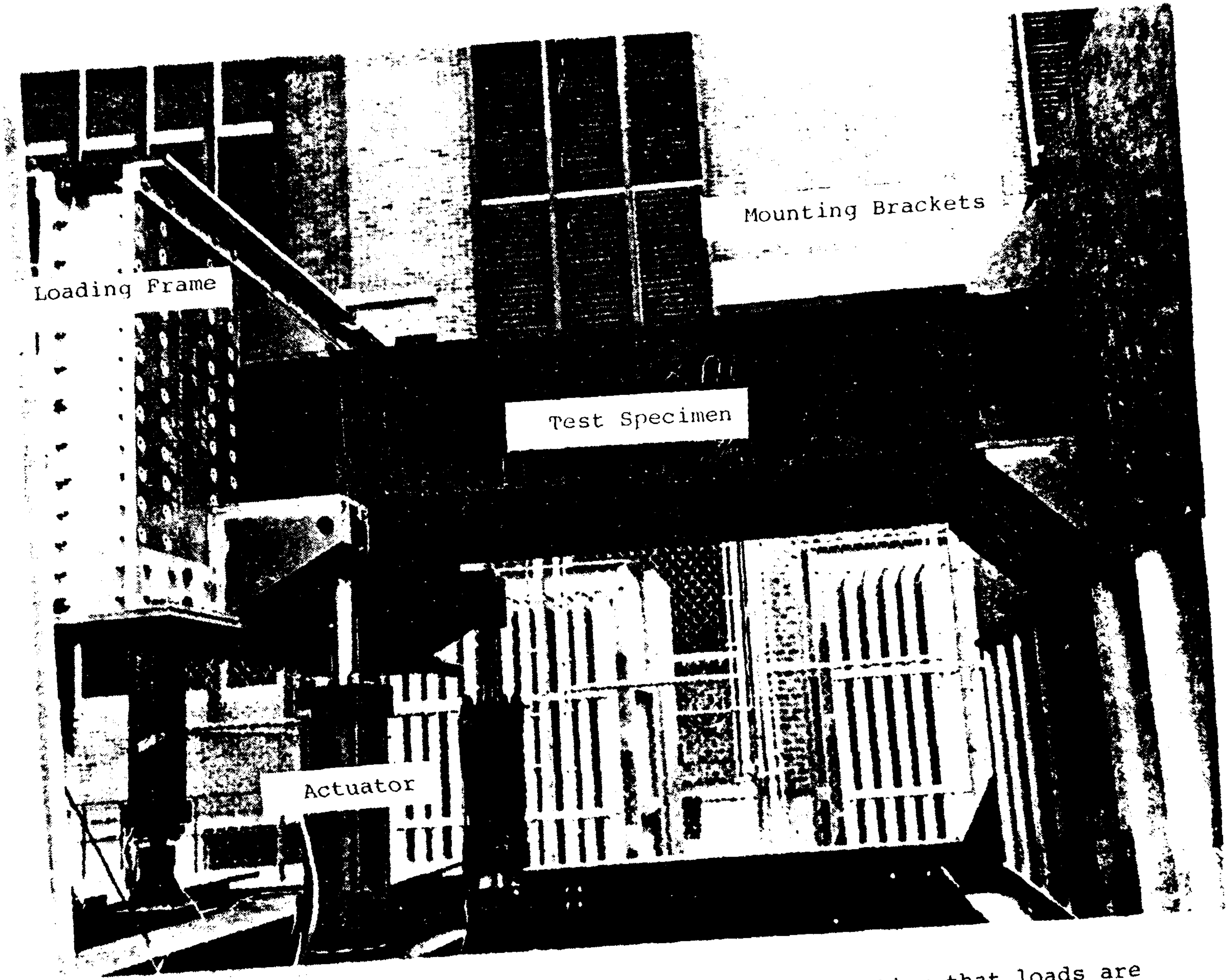


Figure 2.11.1a. An experimental wing test fixture illustrating that loads are applied throughout the end of the wing in the actual test situation.

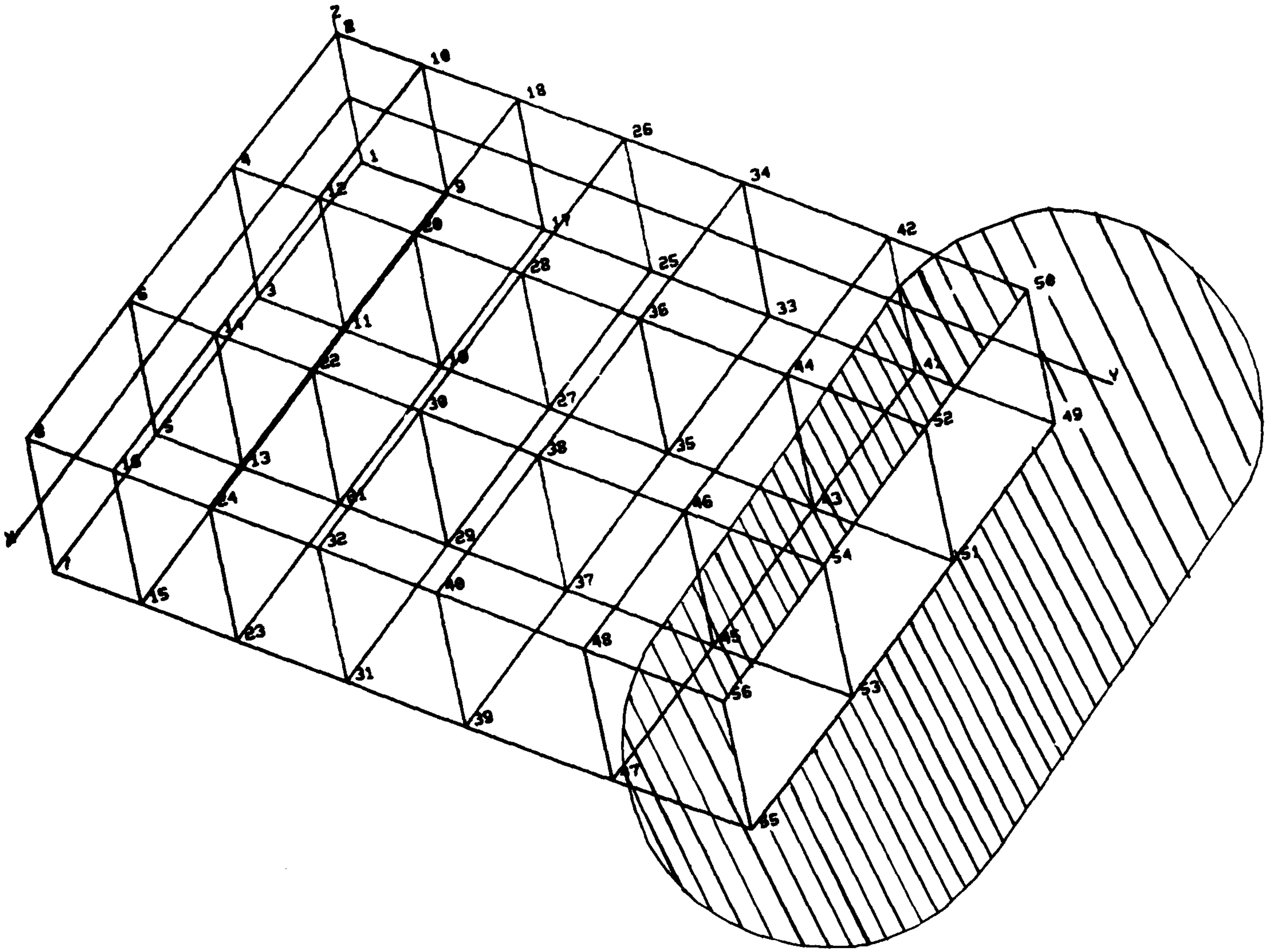


Figure 2.11.1b. A replica wing test specimen finite element model. All loads specified for the analysis of this model will be distributed over the nodes of the load end. Nodes 49 through 56 will be given loads as selected by the user and distributed by the program.

a distributed load on a test specimen and b is a diagram of a wing model with nodes at which loads will be applied. The survivability/vulnerability engineer will be primarily concerned with five types of forces applied to the wing section: chordwise shear (Vc), spanwise shear (Vs), torque (Mt), chordwise moment (Mc) and spanwise moment (Ms) as illustrated in Figure 2.11.2. WINGEN provides for all five of these types of loadings with both of the input options 'TEST' and 'FIXTURE' described in Section 2.8.12. In either case all the loads are resolved into x, y and z load magnitudes which are then distributed among the nodes based on a calculated effective nodal area. This effective nodal area is different for the two options but the effect is identical in that each node on the load plane is assigned a fraction of the total load based on its total effective area. The following equations will help to explain this where A_{ei} is the total effective area of the i^{th} node, A_T is the total effective area of all the nodes and L is the total load applied to the simulated model system.

$$\sum_{i=1}^{n} A_{ei} = A_T \qquad (2.11.1)$$

$$\frac{A_{ei}}{A_T} L = L_i \qquad (2.11.2)$$

$$\sum_{i=1}^{n} L_i = L \qquad (2.11.3)$$

Equation 2.11.2 yields the value L_i which represents the total load applied to the i^{th} node. The sum of all the nodal loads will, of course, equal the total load applied as illustrated in Equation 2.11.3. Since the total load is translated into x, y and z direction components, Equations 2.11.1-3 are applied for each component of the load and the sum of all three components equals the total load applied to the system.

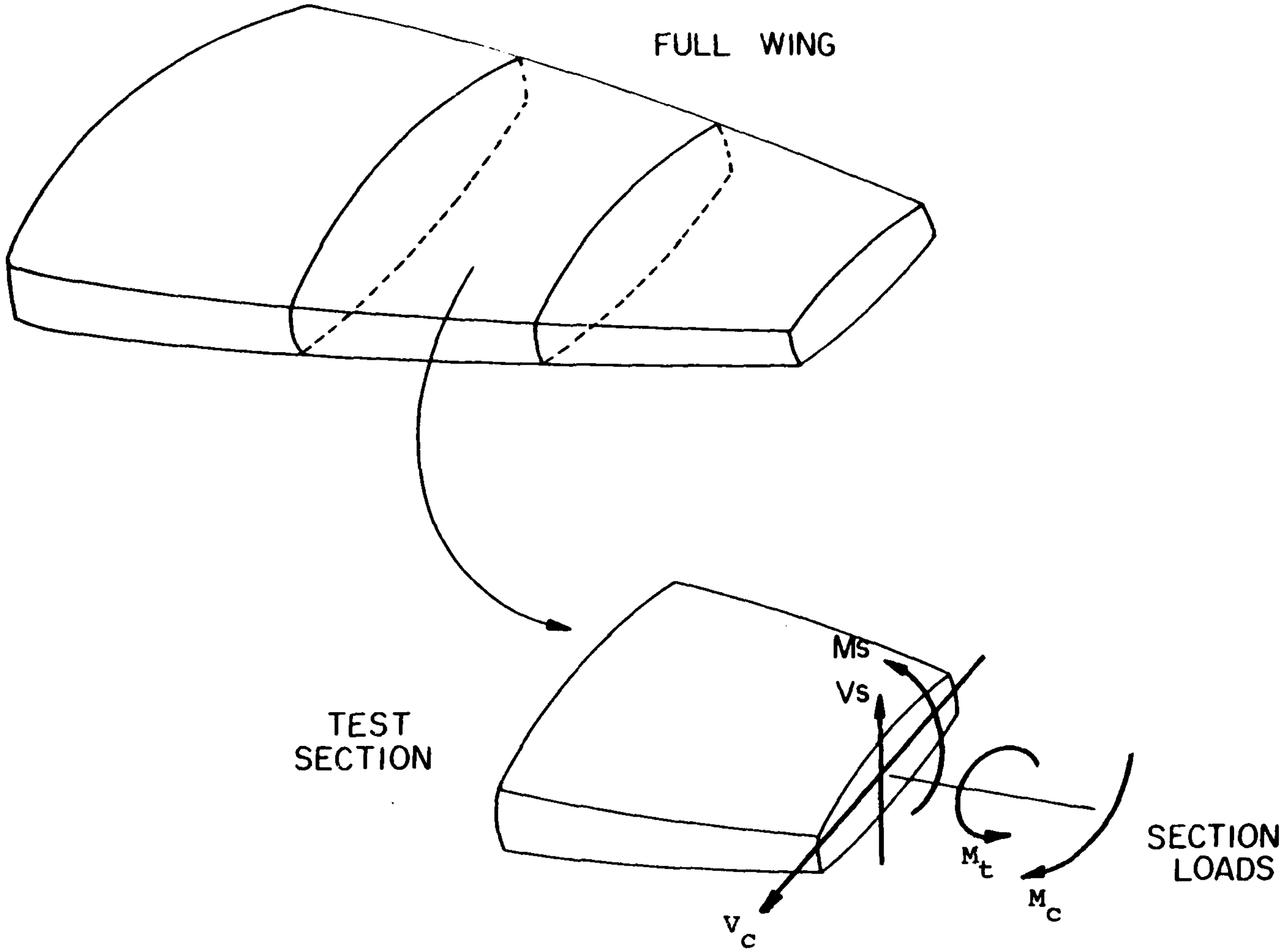


Figure 2.11.2. Types of loads pertinent to the survivability/vulnerability engineer for analyzing wing structures. V_c and V_s are chordwise and spanwise shear loads; M_c and M_s are chordwise and spanwise moments; and M_t is a torque moment. All arrows indicate positive force directions.

2.11.1.1 Load Directions

All loads designations in this manual are such that loads will be positive or all resultants will be positive. The chordwise and spanwise shear forces (V_c, V_s) are positive in the positive x and z directions respectively. A torque moment (M_t) is such that a positive torque force will yield a resultant force in the positive y direction (the right-hand rule will have the thumb pointing in the positive y direction). Positive chordwise and spanwise moments (M_c, M_s) will likewise yield resultant forces in the positive z and positive x directions respectively (e.g., the right-hand rule will yield the thumb pointing in the positive z and x directions).

2.11.1.2 Test Loads

The 'TEST' loads input option is designed to input any or all of five types of loads pertinent to the survivability/vulnerability engineer. These five loads are chordwise and spanwise shear loads (V_c, V_s) torque load (M_t) and spanwise and chordwise moment loads (M_s, M_c). These are illustrated in Figure 2.11.2. WINGEN will input these loads and convert them to x, y and z components and distribute them across the load plane at the nodes based on the effective load area of each node. The resolution of the input loads into the various components is a multi-step process. In the first step the loads are multiplied by the appropriate equations to yield the valid forces components for swept wings. Equations 2.11.4 - 2.11.9 illustrate the data input procedure. The value ALPHA is the sweep angle of the wing.

$$F_x = V_c \tag{2.11.4}$$

$$F_y = V_y \tag{2.11.5}$$

$$F_z = V_s \tag{2.11.6}$$

$$M_x = M_x * \text{COS (ALPHA)} + M_y * \text{SIN(ALPHA)} \tag{2.11.7}$$

$$M_y = M_y^* \text{ COS (ALPHA)} - M_x^*\text{SIN(ALPHA)} \qquad (2.11.8)$$

$$M_z = M_t \qquad (2.11.9)$$

The program next calculates the effective load area for each node and computes the total effective load area. To do this the program assumes certain experimental conditions are being simulated. The experimental test fixture illustrated in Figure 2.11.1a is an example of the clamp and bolt test apparatus this program was designed to simulate. This type of apparatus is characterized by attaching the main clamp of the loading end to the skin panels of the test specimen. The net effect of this procedure is that the skin area alone carries the load distribution from the actuators applying the load to the remaining structure. In reproducing the experimental situation a model simulation must distribute the loads to the individual nodes in a fashion similar to the load distribution in the experimental situation. To accomplish this the 'TEST' option determines the total area of the skin coincident with the load plane and apportions it to each individual node. This is accomplished by dividing each bay in half and combining the two halves to either side of a node to yield a length l_i for each node. This length, l, is then multiplied by the thickness of the skin to generate the effective load area of the node. This process is illustrated in Figure 2.11.3. All the effective nodal load areas are added to yield the total effective load area. The loads are then distributed over the nodes. Each node is taken in turn through equations 2.11.10 - 2.11.12 until all nodes in the load plane have had the full load distributed over them.

$$L_{ix} = \frac{F_x}{n} + \frac{M_y{*}A_{ei}{*}R_z}{A_t} \qquad (2.11.10)$$

$$L_{iy} = \frac{F_y}{n} - \frac{M_x{*}A_{ei}{*}R_z}{A_t} + \frac{M_y{*}A_{ei}{*}R_x}{A_t} \qquad (2.11.11)$$

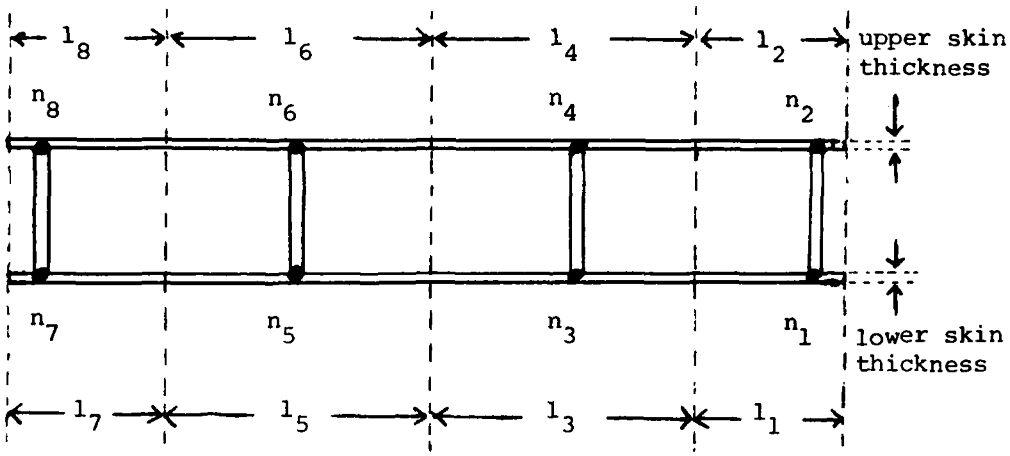


Figure 2.11.3. Test option loads distribution. Each bay is divided in half and each half bay is associated with the node adjacent to it. The length of this upper skin associated with each node is then multiplied by the skin thickness to obtain an effective area for the node, A_e. A_e is divided by the total effective area, A_T, to find the fraction of the load to be applied at that node.

$$L_{iz} = \frac{F_z}{n} - \frac{M_y*A_{ei}*R_x}{A_t} \qquad (2.11.12)$$

In these equations, L_i represents the load applied to the i^{th} node in the x, y or z direction; F represents the total shear force in the x, y or z direction; n is the number of nodes to which loads will be applied; M is the moment in the x or y directions; A_t is the total effective node load area for loads application; A_{ei} is the effective node load area for the i^{th} node; and R is the radius from the center of the load plane to the node in the x or z direction. The load plane is defined by WINGEN to be perpendicular to the y axis and all values affected are adjusted accordingly by the following equations:

$$x_i = x_i*COS(THETA) - Y_i*SIN(THETA) \qquad (2.11.13)$$

$$y_i = y_i*COS(THETA) + x_i*SIN(THETA) \qquad (2.11.14)$$

where x_i and y_i represent the x and y coordinates of the i^{th} node and theta is the angle between the perpendicular load plane and the wing tip that contains all the nodes to which the loads are to be applied. WINGEN calculates the angle theta and does all transformations.

2.11.1.3 Fixture Loads

An alternate method for detailing load input to the nodes is with the FIXTURE option. This method allows the user to specify the loads in terms of a magnitude of the load and the x, y and z distances from the center of the loaded plane to where the load should be applied. WINGEN will take this load and resolve it into its components and distribute it across the nodes of the load plane. As with the 'TEST' case the center of the load plane may be adjusted to be wherever the user wishes. The method of determining the area over which the loads should be applied is slightly different than discussed above for the 'TEST' option. In the 'TEST' option the effective node area for loads application was calculated using the thickness of the skin and the length of the skin 'affected' by each node. The 'FIXTURE' option is based on a different experimental test concept which has the entire load plane active in distributing the load through the structure via some type of end plate or other similar device. To compute the effective node area the program uses the full depth of the wing and computes a real area bounded by the node as illustrated in Figure 2.11.4. To obtain this area each bay is divided into halves and each half is associated with the nearest node. The total of each of these half areas equals the total effective area of that node. The sum of all of these area yields the total effective area for the load plane. Equations 2.11.15 - 2.11.20 show how the input loads are resolved to standard forces:

$$F_x = V_x \tag{2.11.15}$$

$$F_y = V_y \tag{2.11.16}$$

$$F_z = V_z \tag{2.11.17}$$

$$M_x = V_z*R_y - V_y*R_z \tag{2.11.18}$$

$$M_y = V_x*R_z - V_z*R_x \tag{2.11.19}$$

$$M_z = V_y*R_x - V_x*R_y \tag{2.11.20}$$

when R_x, R_y and R_z are the distances from the center of the loaded plane to the point where the load is applied. WINGEN then applies Equations 2.11.10 - 2.11.14 to the forces calculated and yields a distribution of loads across the load plane nodes.

2.11.2 Damage and Modify Directives

WINGEN provides the user with a set of options to specify alterations to the basic wing model geometry. These options, described in Sections 2.8.8 and 2.8.11, adhere to basic

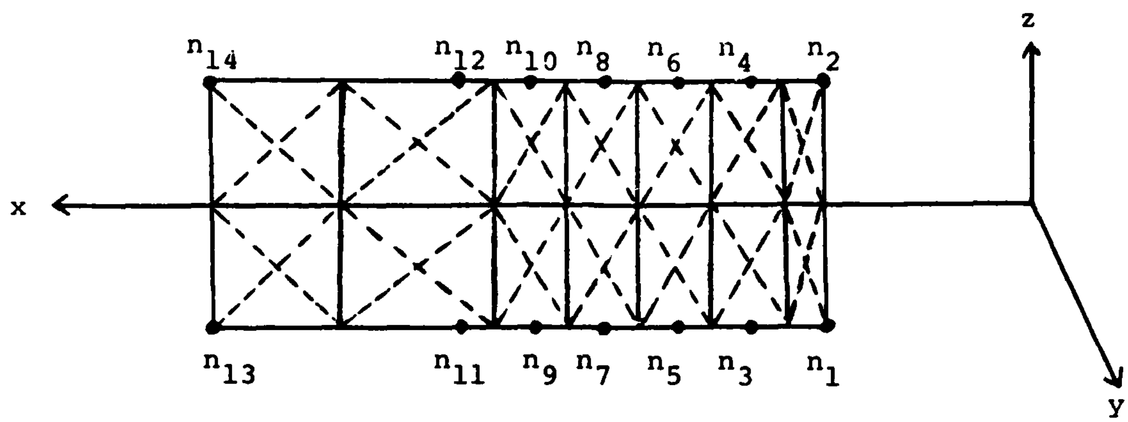


Figure 2.11.4. Loads are distributed across the load plane at each node based on the area encompassed by each node. Dashed x's above indicate the area for each node. Nodes 11 and 12 will have the largest loads applied; nodes 1 and 2, the smallest loads. This is an end-on view of a T-38 wing tip.

fundamental criteria for finite element modeling such that no elements or nodes are in violation of the basic modeling criteria. The first of these criteria is that no element should intersect more than one element on a side without special restrictions. An example of this is given in Figure 2.11.5 where an additional rib has been added to the T-38 wing model. In order to accommodate this violation certain linear constraints must be defined in the input data file (load deck) before an analysis can be performed by MAGNA. These constraint equations are disected to the various components and entered in the data file as described in Sections 8.6 and 8.7 of Reference 1. Table 2.11.1 lists the two sets of constraint data entered in the program for the above problem.

TABLE 2.11.1

LINEAR CONSTRAINT EQUATION TERMS

EQUATION	TERM	NODE #	DIRECTION	MULTIPLIER
lower skin constraint equation terms	1	53	1	1.
	2	39	1	-.4102
	3	67	1	-.5898
	4	53	2	1.
	5	39	2	-.4102
	6	67	2	-.5898
	7	53	3	1.
	8	39	3	-.4102
	9	67	3	-.5898
upper skin constraint equation terms	1	54	1	1.
	2	40	1	-.4102
	3	68	1	-.5898
	4	54	2	1.
	5	40	2	-.4102
	6	68	2	-.5898
	7	54	3	1.
	8	40	3	-.4102
	9	68	3	-.5898

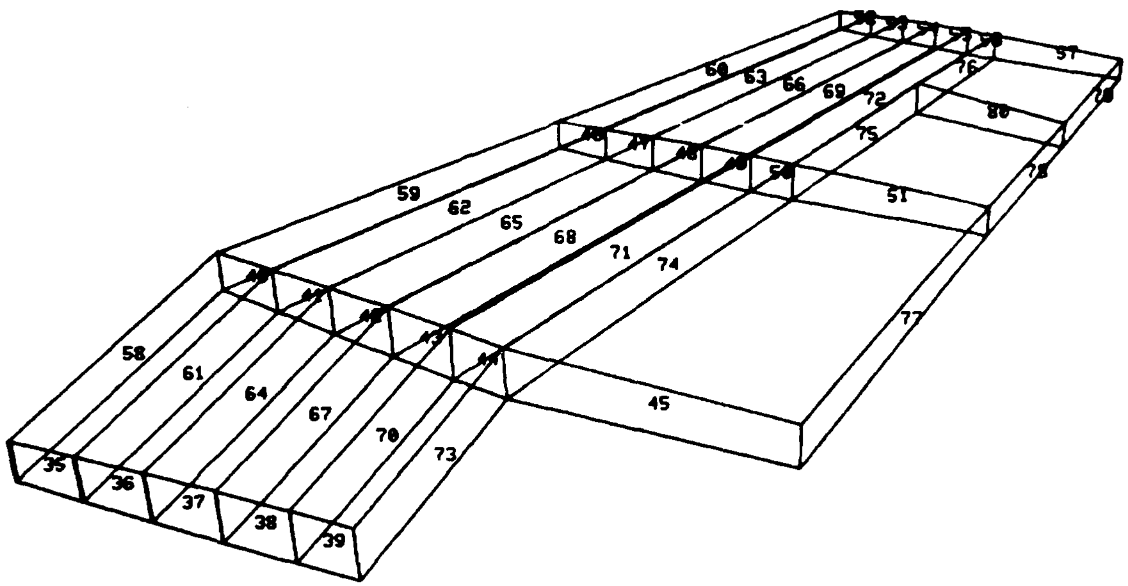


Figure 2.11.5. Special modifications can be made to structures. Illustrated here is a T-38 wing model with an extra rib defined (element #80) which extends only between 2 spars - special constraints are required to allow for a valid analysis.

These equations serve to effectively prevent the elements a and b of Figure 2.11.6 from displacing in a manner different than element c under loading conditions.

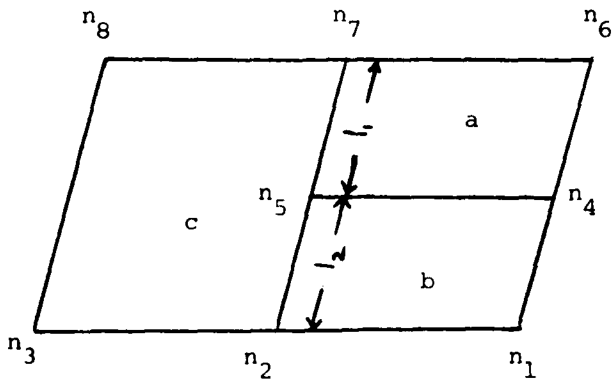


Figure 2.11.6. An example of an incompatible element alignment between elements a, b and c, above. (This is presented in Figure 2.11.5.)

This is accomplished by essentially specifying that node n_5 will not be displaced any more than a linear displacement of nodes n_2 and n_7. The terms listed in Table 2.11.1 would relate node 53 with n_5, node 39 with n_2 and node 67 with n_7 where node n_5 is the constrained node. To obtain the multipliers for this case (remember this is a skin element constraint) the length of the bay is taken and a proportion is established for the relative constraining requirements placed on each node. The multipliers of nodes n_2 and n_7 are given by equations 2.11.21 and 2.11.22. The multiplier for node n_5 is 1.0 as demonstrated by equation 2.11.23.

$$M_{n_2} = \frac{-l_1}{l_1+l_2} \qquad (2.11.21)$$

$$M_{n_7} = \frac{-l_2}{l_1+l_2} \qquad (2.11.22)$$

$$M_{n_5} = \frac{l_1}{l_1+l_2} + \frac{l_2}{l_1+l_2} = 1.0 \qquad (2.11.23)$$

For these equations l_1 represents the distance between nodes n_7 and n_5 while l_2 represents the distance between nodes n_2 and n_5 as illustrated in Figure 2.11.6.

Any alterations made to the model element to yield a structure which is perhaps more accurate but that contains elements which are not uniform throughout the structure must have linear constraints described for the non-uniform union of the incompatible element types. To obtain a structure such as the T-38 wing illustrated in Figure 2.11.5 the user had to alter the load deck file by appending the additional four nodes to the node coordinate list and add the element connectivity for the new rib section. In addition new element connectivities were given for the plate elements (upper and lower skins) and two new plate elements were generated outboard of the new spar. Linear constraints were also added as detailed above to ensure continuity of the stresses and displacements between elements. An alternate method to accomplish the addition of this short rib would have been to specify the definition of a normal rib when the model was created. Once the load deck file was generated the user could essentially remove the unneeded rib elements by defining a new material property code with identical values for all components as the original property code but with a considerably higher yield stress value ($1.1*10^{20}$). To prevent the elements from being utilized in the analysis a very small thickness for the element should be specified ($1.0*10^{-20}$) along with the change to the new material property code. These two changes to an element will remove it from any effective role in the analysis. This latter method is very convenient if a large file is being generated by the preprocessor that would take a considerable period of time to alter or a large number of short ribs need to be defined. This second method also eliminates the requirements of inputting the linear constraints although model plots will show the additional rib which may or may not be important to the project engineer.

A second important criteria for finite element modeling is that all nodes defined for a model must either be utilized in element connectivities or must be constrained in all directions. Any superfluous nodes generated by the program will be so constrained but if the user should add any additional nodes or delete any elements which would result in nodes not being utilized in elements, then the user must be careful to add these to the list of nodes to be constrained. Figure 2.11.7 shows a portion of the constraint data contained on the WINGEN Load Deck after user modification to constrain nodes for an additional rib section (Element number 80 in Figure 2.11.5) inserted into the T-38 wing model. The first three lines of this figure contain information about the last element type defined and end-of-element processing cards (2 blank cards). The fourth card contains information defining the boundary conditions for the model. The first three values of the fourth card specify the number of types 1, 2 and 3 constraints to be defined while the fourth and fifth variables define the number of linear constraint equations and the maximum number of terms per constraint equation, respectively. Two lines are required for each type 1 or 2 constraint definition. Since three type 1 and 2 constraints are specified, the next six lines tell MAGNA that nodes 1 through 16, 25 through 28 and 43 through 52 are all constrained to zero displacements in all directions (for designation of directions MAGNA interprets 1 as x, 2 as y and 3 as z based on a Cartesian coordinate system). Following the boundary constraints are the linear constraints. The eleventh line tells how many terms are in the next equation and the program then reads those terms. Two constraint equations are defined here, with nine terms per equation. The last line indicates the number of load cases to follow. The linear constraints illustrated here are derived from the element situation illustrated in Figure 2.11.6. Further information may be obtained from the MAGNA User's Manual

(Reference 1). Nodes that are not utilized in element generation must be constrained using type 1 or 2 constraints.

The Damage and Modify options are deletion directives in that they specify the removal of various elements. With practice the user can become adept at defining structures and specifying damage or modification to very particular areas by combining several of the damage/modification directives with the refinement options. Additional model editing as described above should allow the definition of any wing structure likely to require modeling.

```
121    1          [illegible]  [illegible]   .[illegible]

  2    1   [illegible]  [illegible]  [illegible]
  1   16    1
  1    2    3
 43   52    1
  1    2    3
  1    2    3
 25   26   27   28
  9
 53    1          1.    39    1   -.4102    67    1   -.[illegible]   53    2       1.
 39    2   -.4102     67    3   -.3394    53    3         1.    39    3   -.4102
 67    3   -.3368
  9
 54    1          1.    40    1   -.4102    68    1   -.5896    54    2       1.
 40    2   -.4102     68    3   -.[illegible]    54    3         1.    40    3   -.4102
 68    3   -.3368
  1
```

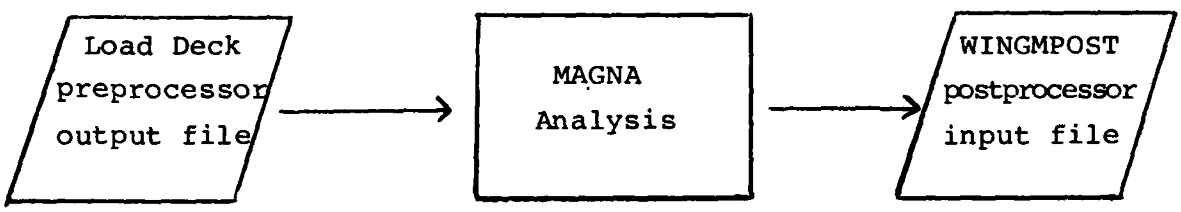
Figure 2.11.7. Load Deck Constraint Data for MAGNA. This figure is an excerpt of 19 lines from the load deck file created by WINGEN and later altered by a user.

SECTION 3
FINITE ELEMENT ANALYSIS PROGRAM MAGNA

3.1 INTRODUCTION

The backbone of any finite element modeling and analysis is the program that actually performs the analysis. This application makes use of the MAGNA finite element analysis program. MAGNA was developed as a finite element program for the materially and geometrically nonlinear analysis of 3-D structures subjected to static and transient loading conditions. The requirements of this application call for a program with restart capabilities, elastic-plastic (material nonlinear solution) capability, large deflection (geometric nonlinear solution) capability and an appropriate finite element library. MAGNA meets these needs easily. The requirements of wing flight load simulation do not utilize a number of features incorporated into MAGNA thus these features will not be discussed in this report. Reference 1 provides a detailed discussion of MAGNA and how to utilize it for finite element analysis.

Illustrated below is the basic operating scheme for MAGNA.



This section of the report will deal with these three components of the MAGNA environment. The user must first define an input file of data which defines the nature of the problem to be solved and provides all of the information in terms of model definition, boundary conditions and loads to be applied. The generation of such a file can be very time consuming and laborious. As a result the preprocessor program WINGEN was developed to alleviate the burden of generating much of the file required by MAGNA. The file discussed in Section 3.2 is the file output by WINGEN for MAGNA analysis. Once the analysis is complete MAGNA will produce two output files. The first will be a printed tab of the analysis results in a legible form for the engineer to consult; the second output will be a disk file or WINGMPOST file for use by the postprocessor programs CONTOUR and PLOTBOB. The WINGMPOST file will contain essentially the same data as is printed on the tab but in different formats.

3.2 PREPROCESSOR OUTPUT FILE/ANALYSIS INPUT DATA FILE

The sole function of the preprocessor program WINGEN is to produce a complete data file (load deck) of a finite element model for analysis by MAGNA from simplified input directives. Upon input of the load deck parameters WINGEN will place all necessary data on local file TAPE11 for the user's access following the preprocessor program execution. Included on TAPE11 are necessary items such as job control cards, load data, nodal coordinates, element connectivities, MAGNA control parameters, etc. Figure 3.2.1 is a complete listing of a sample load deck created by WINGEN (for input to MAGNA). Should the user require more detailed information than is provided below, he should consult Reference 1.

Following the execution of WINGEN, the user will find all the load deck information described in this section on TAPE11. This is a local file and must be saved by the user if he desires to use it again in the future. The file may be saved with standard Request, Copy and Catalog commands as described in the CDC NOS/BE operating manuals (Reference 2).

3.2.1 Job Control Cards

The data stored on TAPE11 consists of 3 data records:

(1) the job control cards;

(2) program directive and model definitions; and

(3) space requirements for the analysis program to run.

The job control cards are standard and are fully explained in the CDC reference manual (Reference 2). Figure 3.2.2 illustrates the first data record in the load deck.

This record contains the MAGNA job control cards. The cards are numbered from 100 to 170 for discussion below. Line 100 is the job card and contains information for the

```
I       UBSK,T500,IO600,CM135000,STCSA. VVVVVVV,BRUNER,RI565,2293018.
        SET,R1=MFL.
        COPYCR,INPUT,TAPES.
        REQUEST,MPOST,*PF.
        ATTACH,P,MAGNAJCL,ID=BROCKMAN,MR=1.
        BEGIN,XMAGNA,P,MAIN,,R1+B.
        CATALOG,MPOST,WINGMPOST,RP=600.
        EOR
    1    REPLICA TEST SPECIMEN

          1    1    1    1    0    1    1    0    0    0    1
          1    1
          1.0000     0.0000
II  2      .2500      .5000
          0.0000     0.0000
        COORDINATES        56
              1      0.0000     0.0000    -8.8750
              2      0.0000     0.0000     8.8750
              3     17.9700     0.0000    -8.8750
              4     17.9700     0.0000     8.8750
    3         5     35.9100     0.0000    -8.8750
              6     35.9100     0.0000     8.8750
              7     53.8800     0.0000    -8.8750
              8     53.8800     0.0000     8.8750
              9      0.0000     9.3000    -8.8750
             10      0.0000     9.3000     8.8750
             11     17.9700     9.3000    -8.8750
             12     17.9700     9.3000     8.8750
             13     35.9100     9.3000    -8.8750
             14     35.9100     9.3000     8.8750
             15     53.8800     9.3000    -8.8750
             16     53.8800     9.3000     8.8750
             17      0.0000    19.6000    -8.8750
             18      0.0000    19.6000     8.8750
             19     17.9700    19.6000    -8.8750
             20     17.9700    19.6000     8.8750
             21     35.9100    19.6000    -8.8750
             22     35.9100    19.6000     8.8750
             23     53.8800    19.6000    -8.8750
             24     53.8800    19.6000     8.8750
             25      0.0000    31.2000    -8.8750
             26      0.0000    31.2000     8.8750
             27     17.9700    31.2000    -8.8750
             28     17.9700    31.2000     8.8750
             29     35.9100    31.2000    -8.8750
             30     35.9100    31.2000     8.8750
             31     53.8800    31.2000    -8.8750
             32     53.8800    31.2000     8.8750
             33      0.0000    43.9000    -8.8750
             34      0.0000    43.9000     8.8750
             35     17.9700    43.9000    -8.8750
             36     17.9700    43.9000     8.8750
             37     35.9100    43.9000    -8.8750
             38     35.9100    43.9000     8.8750
             39     53.8800    43.9000    -8.8750
             40     53.8800    43.9000     8.8750
             41      0.0000    59.6000    -8.8750
             42      0.0000    59.6000     8.8750
             43     17.9700    59.6000    -8.8750
             44     17.9700    59.6000     8.8750
```

Figure 3.2.1. Sample Load Deck for Replica Wing Model. Load Deck example. The next several pages are a listing of a load deck created by WINGEN for initiating and performing a finite element analysis. This figure is divided into the three records on the file: I. Job Control Language, II. Problem Definition Data and III. MAGNA Space Requirements. The problem definition data is subdivided into 10 parts discussed separately in the text.

	45		36.9100	59.6000	-8.8750				
	46		36.9100	59.6000	8.8750				
	47		53.8800	59.6000	-8.8750				
	48		53.8800	59.6000	8.8750				
	49		0.0000	74.5000	-8.8750				
	50		0.0000	74.5000	8.8750				
	51		17.9700	74.5000	-8.8750				
	52		17.9700	74.5000	8.8750				
	53		36.9100	74.5000	-8.8750				
	54		36.9100	74.5000	8.8750				
3	55		53.8800	74.5000	-8.8750				
	56		53.8800	74.5000	8.8750				
	3	2	74						
4	.1000E+08		.3000E+00	.00085900	10000.00				1
	.3000E+08		.3300E+00	.00072500	30000.00				1
	1	1	1	1	3	11	9	.2500	
	2	1	1	2	4	12	10	.2500	
5	3	1	1	3	5	13	11	.2500	
	4	1	1	4	6	14	12	.2500	
	5	1	1	5	7	15	13	.2500	
	6	1	1	6	8	16	14	.2500	
	7	1	1	9	11	19	17	.2500	
	8	1	1	10	12	20	18	.2500	
	9	1	1	11	13	21	19	.2500	
	10	1	1	12	14	22	20	.2500	
	11	1	1	13	15	23	21	.2500	
	12	1	1	14	16	24	22	.2500	
	13	1	1	17	19	27	25	.2500	
	14	1	1	18	20	28	26	.2500	
	15	1	1	19	21	29	27	.2500	
	16	1	1	20	22	30	28	.2500	
	17	1	1	21	23	31	29	.2500	
	18	1	1	22	24	32	30	.2500	
	19	1	1	25	27	35	33	.2500	
	20	1	1	26	28	36	34	.2500	
	21	1	1	28	30	38	36	.2500	
	22	1	1	29	31	39	37	.2500	
	23	1	1	30	32	40	38	.2500	
	24	1	1	33	35	43	41	.2500	
	25	1	1	34	36	44	42	.2500	
	26	1	1	35	37	45	43	.2500	
	27	1	1	36	38	46	44	.2500	
	28	1	1	37	39	47	45	.2500	
	29	1	1	38	40	48	46	.2500	
	30	1	1	41	43	51	49	.2500	
	31	1	1	42	44	52	50	.2500	
	32	1	1	43	45	53	51	.2500	
	33	1	1	44	46	54	52	.2500	
	34	1	1	45	47	55	53	.2500	
	35	1	1	46	48	56	54	.2500	
	36	3	2	9	11	12	10	.1000	
	37	3	2	11	13	14	12	.1000	
	38	3	2	13	15	16	14	.1000	
	39	3	2	17	19	20	18	.1000	
	40	3	2	19	21	22	20	.1000	
	41	3	2	21	23	24	22	.1000	
	42	3	2	25	27	28	26	.1000	
	43	3	2	27	29	30	28	.1000	
	44	3	2	29	31	32	30	.1000	
	45	3	2	33	35	36	34	.1000	
	46	3	2	35	37	38	36	.1000	
	47	3	2	37	39	40	38	.1000	
	48	3	2	41	43	44	42	.1000	

Figure 3.2.1. (continued).

	49	3	2	43	45	46	44	.1000	
	50	3	2	45	47	48	46	.1000	
	51	3	2	1	9	10	2	.1875	
	52	3	2	9	17	18	10	.1875	
	53	3	2	17	25	26	18	.1875	
	54	3	2	25	33	34	26	.1875	
	55	3	2	33	41	42	34	.1875	
	56	3	2	41	49	50	42	.1875	
	57	3	2	3	11	12	4	.1250	
	58	3	2	11	19	20	12	.1250	
	59	3	2	19	27	28	20	.1250	
	60	3	2	27	35	36	28	.1250	
	61	3	2	35	43	44	36	.1250	
	62	3	2	43	51	52	44	.1250	
	63	3	2	5	13	14	6	.1250	
	64	3	2	13	21	22	14	.1250	
	65	3	2	21	29	30	22	.1250	
	66	3	2	29	37	38	30	.1250	
	67	3	2	37	45	46	38	.1250	
	68	3	2	45	53	54	46	.1250	
	69	3	2	7	15	16	8	.1875	
	70	3	2	15	23	24	16	.1875	
	71	3	2	23	31	32	24	.1875	
	72	3	2	31	39	40	32	.1875	
	73	3	2	39	47	48	40	.1875	
5	74	3	2	47	55	56	48	.1875	
	4	2	98						
6	.1000E+08	.00025000	10000.00						1
	.3000E+08	.00075000	30000.00						1
	1	1	9	11	.1500				
	2	1	10	12	.1500				
7	3	1	11	13	.1500				
	4	1	12	14	.1500				
	5	1	13	15	.1500				
	6	1	14	16	.1500				
	7	1	17	19	.1500				
	8	1	18	20	.1500				
	9	1	19	21	.1500				
	10	1	20	22	.1500				
	11	1	21	23	.1500				
	12	1	22	24	.1500				
	13	1	25	27	.1500				
	14	1	26	28	.1500				
	15	1	27	29	.1500				
	16	1	28	30	.1500				
	17	1	29	31	.1500				
	18	1	30	32	.1500				
	19	1	33	35	.1500				
	20	1	34	36	.1500				
	21	1	35	37	.1500				
	22	1	36	38	.1500				
	23	1	37	39	.1500				
	24	1	38	40	.1500				
	25	1	41	43	.1500				
	26	1	42	44	.1500				
	27	1	43	45	.1500				
	28	1	44	46	.1500				
	29	1	45	47	.1500				
	30	1	46	48	.1500				
	31	1	1	9	2.6250				
	32	1	2	10	2.6250				
	33	1	9	17	2.6250				
	34	1	10	18	2.6250				

II

Figure 3.2.1. (continued).

35	1	17	25	2.6250
36	1	18	26	2.6250
37	1	25	33	2.6250
38	1	26	34	2.6250
39	1	33	41	2.6250
40	1	34	42	2.6250
41	1	41	49	2.6250
42	1	42	50	2.6250
43	1	3	11	1.8750
44	1	4	12	1.8750
45	1	11	19	1.8750
46	1	12	20	1.8750
47	1	19	27	1.8750
48	1	20	28	1.8750
49	1	27	35	1.8750
50	1	28	36	1.8750
51	1	35	43	1.8750
52	1	36	44	1.8750
53	1	43	51	1.8750
54	1	44	52	1.8750
55	1	5	13	1.8750
56	1	6	14	1.8750
57	1	13	21	1.8750
58	1	14	22	1.8750
59	1	21	29	1.8750
60	1	22	30	1.8750
61	1	29	37	1.8750
62	1	30	38	1.8750
63	1	37	45	1.8750
64	1	38	46	1.8750
65	1	45	53	1.8750
66	1	46	54	1.8750
67	1	7	15	2.6250
68	1	8	16	2.6250
69	1	15	23	2.6250
70	1	16	24	2.6250
71	1	23	31	2.6250
72	1	24	32	2.6250
73	1	31	39	2.6250
74	1	32	40	2.6250
75	1	39	47	2.6250
76	1	40	48	2.6250
77	1	47	55	2.6250
78	1	48	56	2.6250
79	2	9	10	.3000
80	2	11	12	.3000
81	2	13	14	.3000
82	2	15	16	.3000
83	2	17	18	.3000
84	2	19	20	.3000
85	2	21	22	.3000
86	2	23	24	.3000
87	2	25	26	.3000
88	2	27	28	.3000
89	2	29	30	.3000
90	2	31	32	.3000
91	2	33	34	.3000
92	2	35	36	.3000
93	2	37	38	.3000
94	2	39	40	.3000
95	2	41	42	.3000
96	2	43	44	.3000
97	2	45	46	.3000
98	2	47	48	.3000

Figure 3.2.1. (continued).

```
7
3        1        1
         1   2    3
         1   2    3   4      5     6   7   8
         1
II 10    1  49    1          0.00
         1  49    2   18790.00
         1  49    3          0.00
         1  50    1          0.00
         1  50    2  -18790.00
         1  50    3          0.00
         1  51    1          0.00
         1  51    2   37548.00
         1  51    3          0.00
         1  52    1          0.00
         1  52    2  -37548.00
         1  52    3          0.00
         1  53    1          0.00
         1  53    2   37548.00
         1  53    3          0.00
         1  54    1          0.00
         1  54    2  -37548.00
         1  54    3          0.00
         1  55    1          0.00
         1  55    2   18790.00
         1  55    3          0.00
         1  56    1          0.00
         1  56    2  -18790.00
         1  56    3          0.00
         $EOR
III      12000  168
         $EOR
         $EOF
```

```
100=UDSK,T500,IO800,CM136000,STCSA. D770043,BRUNER,RI565.
110=SET,R1=NFL.
120=COPYCR,INPUT,TAPE5.
130=REQUEST,MPOST,*PF.
140=ATTACH,P,MAGNAJCL,ID=BROCKMAN,MR=1.
150=BEGIN,XMAGNA,P,MAIN,,R1+B.
160=CATALOG,MPOST,WINGMPOST,RP=600.
170=*EOR
..
```

Figure 3.2.2. Load deck job control language. Illustrated here are the job control cards provided by WINGEN to execute the MAGNA analysis program.

computer to know who to charge and where to send the output results as well as information on total cpu time, input/output limits and central memory use limits. These defaults for time, I/O and central memory should be sufficient for any model being investigated. Should you obtain a diagnostic in any of these three areas indicating the value (time) has been exceeded, simply increase the value (time) and rerun the program. (In most cases it is possible to restart the MAGNA program. Consult Reference 1 on the use of MAGNA if this becomes a frequent or costly problem.) Lines 110 - 120 set initial execution conditions for MAGNA and place the model analysis input data for MAGNA on local input file TAPE5. Line 130 provides for the capability to make the output file from the analysis (the MPOST file) a permanent file; the command for which is executed at line 160. Lines 140 and 150 actually execute MAGNA. All postprocessing output from the program will be made a permanent file with the name "WINGMPOST". There is a limit of five such files with the same name (cycles) so the user must take caution to make sure there are no more than four cycles present under the name "WINGMPOST" prior to batching the job to the input queue.

3.2.2 Finite Element Model Data

The second record on the load deck file contains all the information about the model needed by MAGNA to perform the indicated analysis. Figure 3.2.1 contains parts 1-10 which are discussed briefly below. More detailed information about these sections may be obtained from Reference 1.

Part one is the problem title. There are three lines available for the user. The first line contains the title card entered by the user to the preprocessor; the subsequent two cards are blank and may be altered to suit particular user needs. All three title lines are placed on CONTOUR postprocessor plots when the LABE command is utilized.

Part two defines the MAGNA program controlling directives. These cards may vary considerably depending on the type of analysis. Some of these values are the response made by the user to the load deck concerning the nature of the analysis which are asked by WINGEN. The additional parameters and controlling cards are supplied by the program as default values for the user-selected options.

Part three contains the nodal coordinate data. This section is identified by the header keyword "COORDINATES" and an associated number indicating the number of nodes defined for this particular model. Following the header card are enough cards to define all the model nodes. Each card contains a node number and the x, y, and z coordinates for that node number.

Part four contains header card information and material property data for an element type (element type 3 in this case). The first card of this section defines the following section of data to be element type 3; that there are two material property codes and the total number of type 3 elements to be defined. The next two lines are the material property codes discussed earlier in the report. If the user is interested in utilizing additional property codes, the total number of material property codes listed on the element header card (parameter two) must be increased by 1 for each such addition and the necessary values (discussed in Section 2.3 - MODEL DEFINITION) to define the material properties must be placed after the first two material properties and before the first element connectivity data.

Part five lists all the element numbers, element subtype, material property codes, nodal connectivities and element thicknesses, respectively, for the element type discussed in part four above. The user should be aware that element subtype 1 of element type 3 will be converted to shell elements if the shell elements option is implemented. The shell elements are 3-D elements of which two dimensions are defined by the original membrane element and the third dimension added is composed of the element thickness. Four new nodes are generated for each membrane element to convert it to a shell element. Each of these new nodes is given coordinates (see part three) to place it the thickness above the upper skin elements or the thickness below the lower skin elements. The user may alter these thicknesses or newly generated coordinates (z components) to more accurately reflect the skin depth variations.

Part six contains information on element type 4. As with part five, there exists a header card with the element type (type 4 in this case), the number of material property codes and the number of type 4 elements to be defined. This header card is followed by the material property codes definitions cards discussed earlier in this report (Section 2.3 - MODEL DEFINITION). Alterations may be made to the material property codes as discussed in part four.

Part seven contains the data defining the type 4 elements: element number, material property code, nodal connectivities and element cross-sectional area, respectively.

Part eight consists of boundary conditions and other constraint information. The preprocessor program will automatically constrain all the nodes on the root chord of the wing model in the x, y, and z directions as this end will generally be fixed by the constraints of the experiment. Other constraints will be generated by WINGEN if the model is refined with a "THICK" directive generating a new depthwise level of nodes. The user may wish to add further constraints depending on experimental designs. Should this occur, he is referred to Section 8.6 - BOUNDARY CONDITIONS in Reference 1 concerning MAGNA input data and Section 2.11 of this report.

Part nine is present only for nonlinear analysis runs and contains information for loading curves for nonlinear static analysis and uniaxial stress-strain data for elastic-plastic materials. These curves are provided by WINGEN and should not require any changes or modifications. Figure 3.2.1 illustrates a linear analysis and, therefore, does not contain this part.

Part ten is the definition of the load data. This information is supplied as the number of load cases for this analysis run followed by as many cards as necessary to define all loads to input. Only one load case is permitted for each nonlinear analysis; however, multiple load cases are permitted for linear analyses. The data defined is the load case number, the node number to which the load is applied, the x, y, or z direction that the load is to affect, and the magnitude of the load.

3.2.3 MAGNA Space Parameters

This completes the model data required for an analysis run. One record trails the model data. This record defines the amount of space required by MAGNA to actually execute the analysis. The user should not have to alter these WINGEN defined values.

All this data is supplied by WINGEN at the conclusion of the run on TAPE11. The user may wish to make alterations to this data prior to making it a permanent file. Nodes and elements may be added or deleted but the user must be careful to resequence all nodes or elements and must make all references to any newly labeled nodes correspond to the new node number. Following this section is an additional sample load deck created by WINGEN (Figure 3.2.3) illustrating a nonlinear analysis input.

3.2.4 MAGNA Program Execution

Due to the large space requirements of analyzing finite element models, MAGNA has been designed as a Batch execution job. This means the user has no control over the program execution once the job is submitted. To initiate a MAGNA analysis job do one of the following:

a) Submit a punched copy of the load deck created on TAPE11 by WINGEN to a card reader.

or b) if TAPE11 was made a permanent file, attach it as a local file and execute a BATCH command as follows:

```
ATTACH,A,WINGLOADECK,...
BATCH,A,INPUT
```

These two commands will result in an analysis being performed.

Regardless of the method selected, the results will be returned as is customary for remote job processing. The following method may be employed to make certain a load deck is made a permanent file following the WINGEN program execution:

```
REQUEST,P,*PF
REWIND,TAPE11,P
COPYBF,TAPE11,P
CATALOG,P,WINGLOADECK,RP=300,...
```

This will then allow the user to execute the Batch command for a MAGNA job run.

```
UDSK,T500,IO600,CM140000,STANY. D770043,BRUNER,KL565,93351-94
SET,R1-MFL.
COPYCR,INPUT,TAPE5.
REQUEST,MPOST,*PF.
ATTACH,P,MAGNAJCL,ID-BROCKMAN.
BEGIN,XMAGNA,P,MAIN,,R1+B.
CATALOG,MPOST,WINGMPOST,RP-600.
          T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
            CASE 6 - THIRD RUN

   1    1    1    1    0    1    1    0    0    0    1
   1    1
    1.0000      0.0000
     .2500       .5000
     .0000       .0000
COORDINATES         70
     1          0.0000      0.0000    -1.9945
     2          0.0000      0.0000     1.9945
     3          6.3900      0.0000    -2.2425
     4          6.3900      0.0000     2.2425
     5         12.8500      0.0000    -2.4440
     6         12.8500      0.0000     2.4440
     7         19.3800      0.0000    -2.5650
     8         19.3800      0.0000     2.5650
     9         25.9900      0.0000    -2.6145
    10         25.9900      0.0000     2.6145
    11         31.5500      0.0000    -2.5940
    12         31.5500      0.0000     2.5940
    13         58.4800      0.0000    -2.1900
    14         58.4800      0.0000     2.1900
    15          0.0000     29.9200    -1.9945
    16          0.0000     29.9200     1.9945
    17          6.4386     28.9677    -2.2425
    18          6.4386     28.9677     2.2425
    19         12.9183     28.0093    -2.4440
    20         12.9183     28.0093     2.4440
    21         19.4446     27.0440    -2.5650
    22         19.4446     27.0440     2.5650
    23         26.0300     26.0700    -2.6145
    24         26.0300     26.0700     2.6145
    25         31.5500     25.2600    -2.5940
    26         31.5500     25.2600     2.5940
    27         58.4800     25.2300    -2.1900
    28         58.4800     25.2300     2.1900
    29         18.1400     64.8000    -1.4927
    30         18.1400     64.8000     1.4927
    31         23.4229     64.8000    -1.6780
    32         23.4229     64.8000     1.6780
    33         28.7156     64.8000    -1.8571
    34         28.7156     64.8000     1.8571
    35         34.0273     64.8000    -1.9765
    36         34.0273     64.8000     1.9765
    37         39.3700     64.8000    -2.0197
    38         39.3700     64.8000     2.0197
    39         43.8300     64.8000    -2.0094
    40         43.8300     64.8000     2.0094
    41         63.8600     64.8000    -1.5771
    42         63.8600     64.8000     1.5771
    43         28.9900     86.1500    -1.2400
    44         28.9900     86.1500     1.2400
    45         33.5700     86.1500    -1.4500
    46         33.5700     86.1500     1.4500
    47         35.9800     86.1500    -1.5500
    48         35.9800     86.1500     1.5500
    49         42.3700     86.1500    -1.7400
    50         42.3700     86.1500     1.7400
    51         46.7800     86.1500    -1.6600
    52         46.7800     86.1500     1.6600
    53         50.4600     86.1500    -1.7100
    54         50.4600     86.1500     1.7100
    55         66.7500     84.2000    -1.3900
    56         66.7500     84.2000     1.3900
    57         36.8200    101.0000    -1.0626
    58         36.8200    101.0000     1.0626
    59         40.6000    101.0000    -1.2043
    60         40.6000    101.0000     1.2043
    61         44.3700    101.0000    -1.3258
    62         44.3700    101.0000     1.3258
    63         48.1400    101.0000    -1.3925
    64         48.1400    101.0000     1.3925
    65         51.9200    101.0000    -1.4229
    66         51.9200    101.0000     1.4229
    67         55.0600    101.0000    -1.4067
    68         55.0600    101.0000     1.4067
    69         69.2700    101.0000    -1.1739
    70         69.2700    101.0000     1.1739

   3        2       70
.1000E+08 .3000E+00 .00025900   10000.00
.3000E+08 .3300E+00 .00072500   30000.00
   1   1   1      1   3  17  15   .2100
   2   1   1      2   4  18  16   .2070
   3   1   1      3   5  19  17   .2200
   4   1   1      4   6  20  18   .2300
   5   1   1      5   7  21  19   .2400
   6   1   1      6   8  22  20   .2440
   7   1   1      7   9  23  21   .2700
   8   1   1      8  10  24  22   .2580
   9   1   1      9  11  25  23   .2980
  10   1   1     10  12  26  24   .2900
  11   1   1     15  17  31  29   .1730
  12   1   1     16  18  32  30   .1750
  13   1   1     17  19  33  31   .1820
  14   1   1     18  20  34  32   .1950
  15   1   1     19  21  35  33   .1970
  16   1   1     20  22  36  34   .2060
  17   1   1     21  23  37  35   .2220
  18   1   1     22  24  38  36   .2160
  19   1   1     23  25  39  37   .2900
  20   1   1     24  26  40  38   .2400
  21   1   1     29  31  59  57   .1120
  22   1   1     30  32  60  58   .1420
  23   1   1     31  33  61  59   .1070
  24   1   1     32  34  62  60   .1160
  25   1   1     33  35  63  61   .1120
  26   1   1     34  36  64  62   .1260
  27   1   1     35  37  65  63   .1720
  28   1   1     36  38  66  64   .1580
  29   1   1     37  39  67  65   .1850
  30   1   1     38  40  68  66   .1660
  31   1   1     39  41  55  53   .1800
  32   1   1     40  42  56  54   .1600
  33   3   1      1   3   4   2   .0800
  34   3   1      3   5   6   4   .0800
  35   3   1      5   7   8   6   .0800
```

Figure 3.2.3. Sample Load Deck for T-38 Wing Model.

36	3	1	7	9	10	8	.0800
37	3	1	9	11	12	10	.0800
38	3	1	15	17	18	16	.1500
39	3	1	17	19	20	18	.1700
40	3	1	19	21	22	20	.2000
41	3	1	21	23	24	22	.2500
42	3	1	23	25	26	24	.3200
43	3	1	25	27	28	26	.0800
44	3	2	29	31	32	30	.1000
45	3	2	31	33	34	32	.1000
46	3	2	33	35	36	34	.1000
47	3	2	35	37	38	36	.1000
48	3	2	37	39	40	38	.1000
49	3	2	39	41	42	40	.1500
50	3	1	57	59	60	58	.0800
51	3	1	59	61	62	60	.1000
52	3	1	61	63	64	62	.0800
53	3	1	63	65	66	64	.0800
54	3	1	65	67	68	66	.1000
55	3	1	67	69	70	68	.1000
56	3	1	1	15	16	2	.0800
57	3	1	15	29	30	16	.2200
58	3	1	29	57	58	30	.1500
59	3	1	3	17	18	4	.0800
60	3	1	17	31	32	18	.0900
61	3	1	31	59	60	32	.0900
62	3	1	5	19	20	6	.0800
63	3	1	19	33	34	20	.0900
64	3	1	33	61	62	34	.0900
65	3	1	7	21	22	8	.0900
66	3	1	21	35	36	22	.0950
67	3	1	35	63	64	36	.0950
68	3	1	9	23	24	10	.1000
69	3	1	23	37	38	24	.1000
70	3	1	37	65	66	38	.1000
71	3	1	11	25	26	12	.1050
72	3	1	25	39	40	26	.1600
73	3	1	39	53	54	40	.1600
74	3	1	53	67	68	54	.1600
75	3	1	27	41	42	28	.0800
76	3	1	41	55	56	42	.0800
77	3	1	55	69	70	56	.0800
78	3	1	53	55	56	54	.1000

4	2	121		
.1000E+08	.00025900		10000.00	
.3000E+08	.00072500		30000.00	
1	1	1	3	.1000
2	1	2	4	.1000
3	1	3	5	.1000
4	1	4	6	.1000
5	1	5	7	.1000
6	1	6	8	.1000
7	1	7	9	.1000
8	1	8	10	.1000
9	1	9	11	.1000
10	1	10	12	.1000
11	1	15	17	.4407
12	1	16	18	.4068
13	1	17	19	.4859
14	1	18	20	.4068
15	1	19	21	.5311
16	1	20	22	.4294
17	1	21	23	.5537

18	1	22	24	.4520
19	1	23	25	1.6206
20	1	24	26	1.1944
21	1	25	27	.1500
22	1	26	28	.1500
23	2	29	31	.1334
24	2	30	32	.1276
25	2	31	33	.1933
26	2	32	34	.1817
27	2	33	35	.3897
28	2	34	36	.3688
29	2	35	37	.6670
30	2	36	38	.6367
31	2	37	39	.8913
32	2	38	40	.8353
33	2	39	41	.5992
34	2	40	42	.5992
35	1	57	59	.2484
36	1	58	60	.1840
37	1	59	61	.3036
38	1	60	62	.2668
39	1	61	63	.4048
40	1	62	64	.2668
41	1	63	65	.5060
42	1	64	66	.3312
43	1	65	67	.5520
44	1	66	68	.3588
45	1	67	69	.2760
46	1	68	70	.2070
47	1	1	15	.1766
48	1	2	16	.1712
49	1	15	29	.4173
50	1	16	30	.3852
51	1	29	57	.3185
52	1	30	58	.2466
53	1	3	17	.1349
54	1	4	18	.1523
55	1	17	31	.1262
56	1	18	32	.1446
57	1	31	59	.1558
58	1	32	60	.1758
59	1	5	19	.1558
60	1	6	20	.1691
61	1	19	33	.1508
62	1	20	34	.1485
63	1	33	61	.1530
64	1	34	62	.1328
65	1	7	21	.1700
66	1	8	22	.2322
67	1	21	35	.1665
68	1	22	36	.1935
69	1	35	63	.1765
70	1	36	64	.1350
71	1	9	23	.2222
72	1	10	24	.2679
73	1	23	37	.2301
74	1	24	38	.2194
75	1	37	65	.2000
76	1	38	66	.1800
77	1	11	25	.3519
78	1	12	26	.3192
79	1	25	39	.2600
80	1	26	40	.1950
81	1	39	53	.2650

Figure 3.2.3. (continued).

```
 82   1     40   54    .2150
 83   1     27   41    .1000
 84   1     28   42    .1500
 85   1     41   55    .1000
 86   1     42   56    .1500
 87   1      1    2    .0000
 88   1      3    4    .0000
 89   1      5    6    .0000
 90   1      7    8    .0000
 91   1      9   10    .0000
 92   1     11   12    .0000
 93   1     15   16    .0000
 94   1     17   18    .0000
 95   1     19   20    .0000
 96   1     21   22    .0000
 97   1     23   24    .0000
 98   1     25   26    .0000
 99   1     27   28    .0000
100   1     29   30    .0000
101   1     31   32    .0000
102   1     33   34    .0000
103   1     35   36    .0000
104   1     37   38    .0000
105   1     39   40    .0000
106   1     41   42    .0000
107   1     57   58    .0000
108   1     59   60    .0000
109   1     61   62    .0000
110   1     63   64    .0000
111   1     65   66    .0000
112   1     67   68    .0000
113   1     69   70    .0000
114   1     53   55    .1000
115   1     54   56    .1000
116   1     53   67    .1000
117   1     54   68    .1500
118   1     55   69    .1000
119   1     56   70    .1500
120   1     53   54    .1000
121   1     55   56    .1500

  2   1
  1  16    1
  1   2    3
 43  52    1
  1   2    3
  1   2    3
 85  26   27   28
  1
  1  57    1     31.47
  1  57    2   2058.63
  1  57    3    142.13
  1  58    1    -31.47
  1  58    2  -2058.63
  1  58    3    142.13
  1  59    1     73.21
  1  59    2   4788.61
  1  59    3   -143.00
  1  60    1    -73.21
  1  60    2  -4788.61
  1  60    3   -143.00
  1  61    1     84.20
  1  61    2   5507.64
  1  61    3     39.51
  1  62    1    -84.20
  1  62    2  -5507.64
  1  62    3     39.51
  1  63    1     96.20
  1  63    2   6292.54
  1  63    3    252.56
  1  64    1    -96.20
  1  64    2  -6292.54
  1  64    3    252.56
  1  65    1     99.82
  1  65    2   6529.25
  1  65    3    505.65
  1  66    1    -99.82
  1  66    2  -6529.25
  1  66    3    505.65
  1  67    1    250.27
  1  67    2  16370.30
  1  67    3    906.03
  1  68    1   -250.27
  1  68    2 -16370.30
  1  68    3    906.03
  1  69    1    148.32
  1  69    2   9701.80
  1  69    3   2415.58
  1  70    1   -148.32
  1  70    2  -9701.80
  1  70    3   2415.58
12000  220
..
```

Figure 3.2.3. (continued).

3.3 MAGNA ANALYSIS

The survivability/vulnerability engineer is primarily concerned with analysis results of structures and determining whether a structure is capable of supporting the desired load given certain extenuating conditions such as inflicted damage on the structure or unusual load conditions. Other information such as alternate load paths present on the structure following damage, failure loads under various conditions and confirmation of wing structure response to experimental loading conditions may also be of interest. The finite element analysis program MAGNA will provide the user with the type of information when the appropriate finite element data is supplied. MAGNA (Materially And Geometrically Nonlinear Analysis) is a large scale computer program for the static analysis of complex three-dimensional engineering structures. Isoparametric modeling techniques are coupled with state-of-the-art numerical analysis and programming methods to provide accurate and efficient solutions for large problems involving highly nonlinear response.

The modeling capabilities for MAGNA include structural elements for truss members (bars), plane stress and plane strain sections (plates), "shear panels", general three-dimensional solid and thin plates and shells. All the finite elements are arbitrarily oriented and are fully compatible in three-dimensional space. Each of the finite elements in MAGNA includes the effects of full geometrical nonlinearities (large displacements, large strains), using a Lagrangian (fixed reference) description of motion. Material nonlinearities, in the form of elastic-plastic behavior; are analyzed using a subincremental strategy which minimizes the error in following the material stress-strain curve. Other features and theoretical developments are contained in the MAGNA User's Manual, Reference 1. The user is referred to that manual for a detailed discussion of MAGNA.

3.4 MAGNA OUTPUT FILE

No structural analysis program is useful if the engineer cannot locate or interpret the data generated. The nature of finite element analysis is that considerable amounts of printed output is generated making it difficult to isolate what is important in determining answers to problems. Plots are used frequently in this area to isolate that data which is most relevant and present it in a form readily comprehendable by the engineer. Printed tabs of the output data are also convenient for a more thorough evaluation of the structural analysis. Figure 3.4.1 is a listing of the major components of a nonlinear analysis output. A linear static analysis will yield a similar output listing. The differences between the two are discussed in each section below. The reader will note that the sample analysis run in Figure 3.4.1 is divided into fourteen parts. Each of these parts will be discussed below.

3.4.1 Header for MAGNA Program (Figure 3.4.1a)

This banner identifies a MAGNA structural analysis run and provides the user with important current information on who to contact if problems arise and when the last system updates were effected. A page of system notes is also included containing information that may or may not be important. If there are any problems with MAGNA, contact the individual named on these pages.

3.4.2 Program Space Requirements (Figure 3.4.1b)

Part two is a summary of the working areas in the program required for the analysis of the structural problem. The user should not have to be concerned with this unless significantly complex models are analyzed or models with considerable refinements are submitted for analysis by MAGNA. If this is the case and problems arise consult the individual listed on the Header Page.

3.4.3 Main Program Listing (Figure 3.4.1c)

This part contains a listing of the main program segment for MAGNA. This is of no value to the engineer or user.

3.4.4 Input Data File (Figure 3.4.1d)

MAGNA will always copy the input data file to the output file prior to executing the analysis. Part four is the complete load deck generated by the preprocessor WINGEN on TAPE11. This file is discussed in Section 3.2 and in detail in Reference 1.

3.4.5 MAGNA Options Selected (Figure 3.4.1e)

MAGNA is a general purpose finite element program and because of that has a large number of available solution options to accommodate a wide range of requirements. Part five lists the solution options selected for the current analysis. Only a very few of these options will be pertinent for simulated wing loads analysis. The reader may refer to Section 2.9 for a discussion of the load deck creation and options selection available.

3.4.6 Nodal Coordinates (Figure 3.4.1f)

Part six provides a listing of the input nodal coordinates for the model finite elements definition.

3.4.7 Element Connectivities (Figure 3.4.1g)

Each model is composed of several types of elements including the truss (bar), plane stress (membrane plate), shear panel (shear plate) and shell elements. This section lists all the input values and the material property codes defined for each element type.

3.4.8 Constraint Data (Figure 3.4.1h)

Part eight is concerned with model displacement restrictions or contraints. The program provides a summary of the boundary conditions imposed on the model both by the experiment and due to damage/modify specifications. Following the boundary conditions is a nodal variable table providing a listing of the model degrees of freedom at each node. The linear constraints imposed on the model are then listed followed by a summary of the matrix required for the problem solution. Finally, a matrix profile map is supplied to assist the user in assuring that the problem was set up correctly.

3.4.9 Stress-Strain Curves (Figure 3.4.1i)

Nonlinear analysis only, requires the input of stress-strain data curves to be utilized in performing the solution. These curves are referenced by the materials definition data for each element and are utilized by MAGNA for material nonlinearities.

3.4.10 Loads Data (Figure 3.4.1j)

Part nine repeats the loads input information that will be utilized in the problem solution. This completes the data input process. The next four sections deal with the output generated by the analytical solution.

3.4.11 Node Displacement (Figure 3.4.1k)

MAGNA will generate a listing of the node displacement and element stress-strain data for each load increment performed in the problem solution. A linear static analysis will have only one increment where as a nonlinear static analysis may have any practical number of increments in the solution. The node displacement list generated for each increment gives the total displacement of the node from the original position. A zero displacement followed by an asterisk indicates a node constrained in that direction.

3.4.12 Element Stresses (Figure 3.4.1l)

All the elements of each element type will be listed with the stresses and strains accumulated up to the increment listed. A linear static analysis will only have one increment and therefore only one solution listing for each element. A nonlinear static analysis will have any reasonable number of solution steps and a listing of stresses and strains will be generated for each solution increment.

3.4.13 Solution Time and I/O Summaries (Figure 3.4.1m)

Part 12 is a listing of solution times for various parts of the program execution and of the input and output operations for program execution. The user will generally not be too concerned about these.

3.4.14 Day File (Figure 3.4.1n)

This last part is a listing of the CDC6600 computer job control cards and execution diagnostics for the execution of MAGNA. The important items to note here are that the analysis ran successfully and that a new WINGMPOST file was successfully cataloged. These conditions are bracketed in Figure 3.4.1n.

This is all the information that is present on the output tab. The engineer should find that all this data is relevant to the structural problem solution. This output listing is designed to be used in conjunction with plots generated by CONTOUR and PLOTBOB which help to describe the alternate load paths and stress/strain distributions as well as nodal deformation under the specified loads. Any questions regarding the output tabs or MAGNA should be directed to the individual listed on the program header as illustrated in Figure 3.4.1a. Figure 3.4.2 is a listing of a linear static analysis output for a T-38 wing model.

```
MATERIALLY AND GEOMETRICALLY
NONLINEAR ANALYSIS
OF
THREE-DIMENSIONAL STRUCTURES

REVISED 01/80
DOCUMENTATION: JDR-TR-79-45

UNIVERSITY OF DAYTON
RESEARCH INSTITUTE
300 COLLEGE PARK
DAYTON OHIO 45469

REQUESTS FOR PROGRAM USE AND AVAILABILITY SHOULD BE REFERRED TO :

        DR. FRED K. BOGNER, GROUP LEADER
        ANALYTICAL MECHANICS GROUP
        RESEARCH INSTITUTE
        UNIVERSITY OF DAYTON
        DAYTON, OHIO  45469

USER QUESTIONS AND COMMENTS REGARDING THIS VERSION OF THE MAGNA
FINITE ELEMENT PROGRAM SHOULD BE DIRECTED TO :

        DR. ROBERT A. BROCKMAN
        RESEARCH ENGINEER
        ANALYTICAL MECHANICS GROUP
        RESEARCH INSTITUTE
        UNIVERSITY OF DAYTON
        DAYTON, OHIO  45469

        TELE. (513)-229-3618

LAST SYSTEM COMPATIBILITY UPDATE  -  NOS / BE , LEVEL 481 D
```

Figure 3.4.1. Unique Sections of a MAGNA analysis output file. This sample of a nonlinear analysis performed on a replica test specimen has been divided in fourteen parts for ease in discussion.

Figure 3.4.1a. MAGNA header

```
MAGNA SYSTEM NOTES :

1.  TO AVOID DIFFICULTY IN ACCESSING THE MAGNA PROCEDURE FILE (MAGNAJCL),
    USE THE PARAMETER MR=1 ON THE CONTROL CARD ATTACHING THE FILE, E.G.,

    ATTACH,P,MAGNAJCL,ID=BROCKMAN,SN=AFFDL,MR=1.

2.  EIGENVALUE SOLUTION (NATURAL FREQUENCIES AND NORMAL MODES) IS NOW
    AVAILABLE IN MAGNA.  DOCUMENTATION WILL BE INCLUDED IN THE NEXT RELEASE
    OF THE USERS MANUAL.

3.  AN AVERAGED STIFFNESS FORMULATION IS NOW AVAILABLE FOR THE VARIABLE-
    NODE SOLID (ELEMENT TYPE 1), WHICH CAN RESULT IN SIGNIFICANT TIME SAVINGS
    FOR NONLINEAR ANALYSIS.  THE OPTION IS TURNED ON ELEMENT BY ELEMENT, BY
    SPECIFYING ISUP=-1 ON THE ELEMENT DEFINITION CARD.  IT IS SUGGESTED THAT
    THIS OPTION BE USED ONLY WITH ITERATION TO MAINTAIN ACCURACY.

4.  THREE NEW ELEMENT TYPES ARE AVAILABLE IN MAGNA WHICH ARE NOT DESCRIBED
    IN THE USERS MANUAL.  ALL THREE ELEMENTS ARE THREE-DIMENSIONAL, AND
    SHOULD BE USED IN PREFERENCE TO ELEMENT TYPE 1 WHEN POSSIBLE BECAUSE
    OF THEIR INCREASED EFFICIENCY.  THE NEW ELEMENTS ARE -

    EL. TYPE 6 - 3-D SOLID 20-NODE BRICK
    EL. TYPE 7 - 3-D SOLID ELEMENT WITH VARIABLE NUMBER OF NODES ( 8 TO 20 )
    EL. TYPE 8 - 3-D SOLID / THICK SHELL WITH 16 NODES

    NODAL CONFIGURATIONS FOR EACH OF THESE ELEMENTS FOLLOW THE SAME CONVENTION
    AS ELEMENT TYPE 1.  INPUT DATA FOR ELEMENTS 6, 7 AND 8 IS EXACTLY THE SAME
    AS FOR ELEMENT TYPE 1 (E.G., THE 16-NODE ELEMENT CONSISTS OF ALL VERTEX
    AND MIDSIDE NODES ON THE UPPER AND LOWER ELEMENT SURFACES, ETC.).  ONLY
    THE ELEMENT TYPE HEADER  MUST BE CHANGED (SEE SECTION 8.5.1 OF MANUAL).
    THE AVERAGED STIFFNESS OPTION (ITEM 3 ABOVE ) IS INCLUDED IN ALL THREE
    OF THE NEW ELEMENT TYPES.

5.  MOST OF THE THREE-DIMENSIONAL ELEMENTS IN MAGNA NOW INCLUDE THE OPTION
    FOR ANALYZING ORTHOTROPIC MATERIALS.  ELEMENT TYPES 1, 6, 7 AND 8
    PRESENTLY HAVE THIS FEATURE.  THEORETICAL DEVELOPMENT AND EXAMPLES OF
    ORTHOTROPIC MATERIAL INPUT DATA ARE DOCUMENTED IN UDR-TM-86-15.  COPIES
    OF THIS MEMO ARE AVAILABLE UPON REQUEST.
```

Figure 3.4.1a. (continued).

```
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

      WORKING ARRAY REDEFINITION                      MAGNA / UPDGEN                 01/03/80      11.37.20.

           LABELLED COMMON AREA          LENGTH          DEFAULT          MINIMUM

                /BLANK/      NWORK   = 12000          24000           12000
                /IDENT/      NID     =   200           2500             100
                /BLOX /      NNS     =   150            150             150
                /BLEQ /      NMS     =   150            150             150
                /INDXK/      NINDXK  =   170            170             170

                                        DECIMAL      OCTAL
      CENTRAL MEMORY ( DEFAULT ) . . .   56320      156000
      ARRAY EXTENSIONS . . . . . . . . .-14300      744043
      CENTRAL MEMORY (ESTIMATED) . . .   42020      122044
```

Figure 3.4.1b. Space Requirements.

```
      PROGRAM MAIN                                                      IOOCT79    1
     +(            TAPE5 =100/90 , OUTPUT=600    , TAPE6 =OUTPUT,       IOOCT79    2
     +             MPOST =160    , TAPE33=MPOST  , TAPE24=512    ,      IOOCT79    3
     +             TAPE10=1000   , TAPE21=600    ,                      IOOCT79    4
     +             TAPE11=512    , TAPE12=1000   , TAPE13=512    ,      IOOCT79    5
     +             TAPE14=512    , TAPE15=512    , TAPE16=512    ,      IOOCT79    6
     +             TAPE17=512    , TAPE18=512    , TAPE20=512    ,      IOOCT79    7
     +             TAPE22=512    , TAPE23=512    , TAPE50=512    )      IOOCT79    8
C                                                                       MAIN      11
      COMMON /BLANK/       A   (   12000 )                              WKAREA     1
      COMMON /IDENT/      ID   (     200 )                              WKAREA     2
      COMMON /BLOX /   NSHFT   (     150 )                              WKAREA     3
      COMMON /BLEQ /  NEQLIM   (     150 )                              WKAREA     4
      COMMON /INDXK/    INDK   (     170 )                              WKAREA     5
      COMMON /POSTPR/ IPP,NPFILE,NETYPU                                 MAIN      17
      COMMON /C32   / I32(11)                                           MAIN      18
      COMMON /C33/   XG(10),WG(10)                                      MAIN      19
      COMMON /C34/   I34(7)                                             MAIN      20
      COMMON /HED1/  TITLE(8,3)                                         MAIN      21
      COMMON /OP/    IOP                                                MAIN      22
      COMMON /INDXM/ IND21(56)                                          MAIN      23
      COMMON /ELTYP1/NELTYP,NDFTYP(20),NEL(20)                          MAIN      24
      COMMON /ELTYP2/NNOD(20),NPAR(10,20),NFORD(20)                     MAIN      25
      COMMON /TIMSTP/ ICTIME(4),CDT(4),NCTIME                           MAIN      26
      COMMON/MPART/N,NLC,NBLK,NLK,NWORK,MAXSTZ,NINDXK,NID,NNS,NO.D,N3OLD MAIN      27
      COMMON/DOF/NFVAR,NDPVPN,NDPN,MAXKOD,NBC1,NBC2,NI,NLCC,NLCT,NLCR   MAIN      28
      COMMON /VCARAY/LVC(100)                                           MAIN      29
      COMMON /CTRL/  NODES,IOPT(20),IPRF,NSTEP,ISTEP                    MAIN      30
      COMMON /DYNINT/ALFA,BETA,GAMA,DLTA,DT,TZERO,T                     MAIN      31
      COMMON / EQIT1/ LCOCOR,INTRVL,MAXIT,EQTOL,DISTOL                  EQMAIN1    1
      COMMON / EQIT2/ PNORM,PNORMP,DNORM,DNORMP                         EQMAIN1    2
      COMMON / EQIT3/ IPRINT,IPOST,NOMAT,NOMATP,LCIT,NUMIT,ITERS,ISTOP  EQMAIN1    3
      COMMON /PCOM1/ PC1(113)                                           MAIN      32
      COMMON /PCOM2/ PC2(51)                                            MAIN      33
      COMMON /PCOM3/ PC3(135)                                           MAIN      34
      COMMON /GRAPH/ ABX(20),ORD(20),NCURV,NPTS(50)                     MAIN      35
      COMMON /FILNAM/ IFILE(15)                                         MAIN      36
      COMMON /ARISO / PAP(1)                                            IOOCT79    9
      COMMON/LOPLOC/LLOC(25)                                            MAIN      38
      COMMON /IMPLD/ PLD(16)                                            MAIN      39
      COMMON /EIGN1/ DATA1(10)                                          EIGEN      1
      COMMON /EIGN2/ DATA2(100)                                         EIGEN      2
      COMMON /USERC/ USPACE(20)                                         MAIN      40
      COMMON /SIO   / IOREQS(4)                                         MAIN      41
C                                                                       MAIN      42
C         NNS      =  150                                               WKAREA     6
          NWORK    =12000                                               WKAREA     7
          NID      =  200                                               WKAREA     8
          NNS      =  150                                               WKAREA     9
          NINDXK   =  170                                               WKAREA    10
      NINDXM=56                                                         MAIN      48
      IOP    =      1                                                   MAIN      49
C                                                                       MAIN      50
      NIN    =      5                                                   MAIN      51
      NOUT   =      6                                                   MAIN      52
C                                                                       MAIN      53
      CALL INITIN (NIN,NOUT)                                            MAIN      54
```

Figure 3.4.1c. Main Program Listing.

```
      IVSET  = IOPT(1)                                           MAIN     55
      GO TO (10,20,500,500,500),IVSET                            MAIN     56
   10 CALL SETUP1                                                MAIN     57
      GO TO 200                                                  MAIN     58
   20 CALL SETUP2                                                MAIN     59
      GO TO 200                                                  MAIN     60
C                                                                MAIN     61
C                                                                MAIN     62
C                                                                MAIN     63
  200 CONTINUE                                                   MAIN     64
      CALL IOINIT (NINDXM,NINDXK)                                MAIN     65
C                                                                MAIN     66
C     1. LINEAR STATIC ANALYSIS                                  MAIN     67
C                                                                MAIN     68
      IF ( IOPT(2).EQ.1  .AND.                                   MAIN     69
     +     IOPT(3).EQ.1  .AND.                                   MAIN     70
     +     IOPT(4).EQ.1       )    CALL CNTL01                   MAIN     71
C                                                                MAIN     72
C     2. LINEAR DYNAMIC ANALYSIS                                 MAIN     73
C                                                                MAIN     74
      IF ( IOPT(2).EQ.2  .AND.                                   MAIN     75
     +     IOPT(3).EQ.1  .AND.                                   MAIN     76
     +     IOPT(4).EQ.1       )    CALL CNTL02                   MAIN     77
C                                                                MAIN     78
C     3. FREE VIBRATION ANALYSIS                                 MAIN     79
C                                                                MAIN     80
      IF ( IOPT(2).EQ.3       )   CALL CNTL03                    EIGEN     3
C                                                                MAIN     82
C     4. NONLINEAR STATIC ANALYSIS                               MAIN     83
C                                                                MAIN     84
      IF ( IOPT(2).EQ.1  .AND.                                   MAIN     85
     +   ( IOPT(3).GT.1  .OR.                                    MAIN     86
     +     IOPT(4).GT.1      ))    CALL CNTL04                   MAIN     87
C                                                                MAIN     88
C     5. NONLINEAR DYNAMIC ANALYSIS                              MAIN     89
C          (IMPLICIT INTEGRATION)                                MAIN     90
C                                                                MAIN     91
      IF ( IOPT(2).EQ.2  .AND.                                   MAIN     92
     +     IOPT(5).EQ.1  .AND.                                   MAIN     93
     +   ( IOPT(3).GT.1  .OR.                                    MAIN     94
     +     IOPT(4).GT.1      ))    CALL CNTL05                   MAIN     95
C                                                                MAIN     96
C     6. NONLINEAR DYNAMIC ANALYSIS                              MAIN     97
C          (EXPLICIT INTEGRATION)                                MAIN     98
C                                                                MAIN     99
      IF ( IOPT(2).EQ.2  .AND.                                   MAIN    100
     +     IOPT(5).EQ.2  .AND.                                   MAIN    101
     +    (IOPT(3).GT.1   .OR.                                   MAIN    102
     +     IOPT(4).GT.1      ))    CALL CNTL06                   MAIN    103
C                                                                MAIN    104
  500 STOP                                                       MAIN    105
      END                                                        MAIN    106
```

Figure 3.4.1c. (continued).

```
SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
24276   MAIN

VARIABLES     SN   TYPE             RELOCATION
     0   A          REAL       ARRAY   BLANK             0   ABX        REAL       ARRAY   GRAPH
     0   ALFA       REAL               DYNINT            1   BETA       REAL               DYNINT
     4   COT        REAL       ARRAY   TIMSTP            0   DATA1      REAL       ARRAY   EIGN1
     0   DATA2      REAL       ARRAY   EIGN2             4   DISTOL     REAL               EQIT1
     3   DLTA       REAL               DYNINT            2   DNORM      REAL               EQIT2
     3   DNORMP     REAL               EQIT2             4   DT         REAL               DYNINT
     3   EQTOL      REAL               EQIT1             2   GAMA       REAL               DYNINT
     0   ICTIME     INTEGER    ARRAY   TIMSTP            0   ID         INTEGER    ARRAY   IDENT
     0   IOP        INTEGER            OP                0   ITTLE      INTEGER    ARRAY   FILNAM
     0   INDK       INTEGER    ARRAY   INDXK             0   IND21      INTEGER    ARRAY   INDXM
     1   INTRVL     INTEGER            EQIT1             1   IORT       INTEGER    ARRAY   CTRL
     0   IOKEQS     INTEGER    ARRAY   SIO               1   IPOST      INTEGER            EQIT3
     0   IPP        INTEGER            POSTPR           25   IPRF       INTEGER            CTRL
     0   IPRINT     INTEGER            EQIT3            27   ISTEP      INTEGER            CTRL
     7   ISTOP      INTEGER            EQIT3             6   ITERS      INTEGER            EQIT3
 24412   IVSET      INTEGER                              0   I32        INTEGER    ARRAY   C32
     0   I34        INTEGER    ARRAY   C34               4   LDIT       INTEGER            EQIT3
     0   LLOC       INTEGER    ARRAY   LODLOC            0   LODFOR     INTEGER            EQIT1
     0   LVC        INTEGER    ARRAY   VCARAY            2   MAXIT      INTEGER            EQIT1
     3   MAXKOD     INTEGER            DOF               5   MAXSIZ     INTEGER            MPART
    10   MLCT       INTEGER            DOF               0   N          INTEGER            MPART
     4   NBC1       INTEGER            DOF               5   NBC2       INTEGER            DOF
     2   NBLK       INTEGER            MPART            12   NBOLD      INTEGER            MPART
    10   NCTIME     INTEGER            TIMSTP           50   NDJPV      INTEGER            GRAPH
     1   NOFTYP     INTEGER    ARRAY   ELTYP1            2   NDPN       INTEGER            DOF
     1   NOPVPN     INTEGER            DOF              25   NEL        INTEGER    ARRAY   ELTYP1
     6   NELTYP     INTEGER            ELTYP1            0   NEQLIM     INTEGER    ARRAY   BLEQ
     2   NLTYPU     INTEGER            POSTPR          334   NF RD      INTEGER    ARRAY   ELTYP2
     0   NEVAR      INTEGER            DOF               6   NI         INTEGER            DOF
     7   NIO        INTEGER            MPART         24410   NIN        INTEGER
     0   NINDXK     INTEGER            MPART         24407   NINDXM     INTEGER
     1   NLC        INTEGER            MPART             7   NLOC       INTEGER            DOF
    11   NLCK       INTEGER            DOF               3   NLR        INTEGER            MPART
     0   NNOD       INTEGER    ARRAY   ELTYP2           10   NNS        INTEGER            MPART
     0   NODES      INTEGER            CTRL             11   NOLD       INTEGER            MPART
     2   NOMAT      INTEGER            EQIT3             3   NOMATP     INTEGER            EQIT3
 24411   NOUT       INTEGER                             24   NPAF       INTEGER    ARRAY   ELTYP2
     1   NPFILE     INTEGER            POSTPR           51   NPTS       INTEGER    ARRAY   GRAPH
     0   NSHFT      INTEGER    ARRAY   BLOX             26   NSTEP      INTEGER            CTRL
     5   NUMIT      INTEGER            EQIT3             4   NWORK      INTEGER            MPART
    24   ORD        REAL       ARRAY   GRAPH             0   P11        REAL       ARRAY   PCOM1
     6   P22        REAL       ARRAY   PCOM2             0   P33        REAL       ARRAY   PCOM3
     6   PLO        REAL       ARRAY   IMPLO             0   PNORM      REAL               EQIT2
     1   PNORMP     REAL               EQIT2             0   PRP        REAL       ARRAY   ANISO
     6   T          REAL               DYNINT            0   TITLE      REAL       ARRAY   HED1
     5   TZERO      REAL               DYNINT            0   USPACE     REAL       ARRAY   USERC
    12   WG         REAL       ARRAY   C33               0   XG         REAL       ARRAY   C33
```

Figure 3.4.1c. (continued).

```
PROGRAM MAIN        74/74    OPT=2                        FTN 4.7+475          01/03/80  11.37.22         PAGE     4

FILE NAMES          MODE
 1435  MPOST                     231  OUTPUT                 3025  TAPE10                6255  TAPE11
 7331  TAPE12                  11355  TAPE13                12431  TAPE14               13565  TAPE15
14561  TAPE16                  15635  TAPE17                16711  TAPE18               17765  TAPE20
 5041  TAPE21                  21041  TAPE22                22115  TAPE23                1751  TAPE24
    0  TAPE5                   23171  TAPE50                  231  TAPE5                 1435  TAPE99

EXTERNALS              TYPE    ARGS
         CNTL01                  0                          CNTL02                 0
         CNTL03                  0                          CNTL04                 0
         CNTL05                  0                          CNTL06                 0
         INITIN                  2                          EDINIT                 2
         SETUP1                  0                          SETUP2                 0

STATEMENT LABELS
24323  10                              24325   20                            24326   200
24377  500

COMMON BLOCKS   LENGTH
         BLANK    12000
         IDENT      200
         BLOX       150
         BLEQ       150
         INDXK      170
         POSTPF       3
         C32         11
         C33         20
         C34          7
         HED1        24
         DP           1
         INDXM       56
         ELTYP1      41
         ELTYP2     240
         TIMSTF       5
         MPART       11
         DOF         10
         VCARAY     100
         CTRL        24
         DYNINT       7
         EQIT1        5
         EQIT2        4
         EQIT3        8
         PCOM1      113
         PCOM2       51
         PCOM3      135
         GRAPH       91
         FILNAM      15
         ANISO        1
         LODLOC      25
         IMPLD       16
         EIGN1       10
         EIGN2      100
         USERC       20
         SID          4
```

Figure 3.4.1c. (continued).

```
REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
      CASE 1
   1   1   2   2   3   1   1                  1
  20   1
        1.         0.
        0.         0.
        0.         0.
COORDINATES        56
   1        0.0000     0.0000   -8.8750
   2        0.0000     0.0000    8.8750
   3       17.9700     0.0000   -8.8750
   4       17.9700     0.0000    8.8750
   5       35.9100     0.0000   -8.8750
   6       35.9100     0.0000    8.8750
   7       53.8800     0.0000   -8.8750
   8       53.8800     0.0000    8.8750
   9        0.0000     9.3100   -8.8750
  10        0.0000     9.3100    8.8750
  11       17.9700     9.3100   -8.8750
  12       17.9700     9.3100    8.8750
  13       35.9100     9.3100   -8.8750
  14       35.9100     9.3100    8.8750
  15       53.8800     9.3100   -8.8750
  16       53.8800     9.3100    8.8750
  17        0.0000    18.6100   -8.8750
  18        0.0000    18.6100    8.8750
  19       17.9700    18.6100   -8.8750
  20       17.9700    18.6100    8.8750
  21       35.9100    18.6100   -8.8750
  22       35.9100    18.6100    8.8750
  23       53.8800    18.6100   -8.8750
  24       53.8800    18.6100    8.8750
  25        0.0000    31.2100   -8.8750
  26        0.0000    31.2100    8.8750
  27       17.9700    31.2100   -8.8750
  28       17.9700    31.2100    8.8750
  29       35.9100    31.2100   -8.8750
  30       35.9100    31.2100    8.8750
  31       53.8800    31.2100   -8.8750
  32       53.8800    31.2100    8.8750
  33        0.0000    43.9100   -8.8750
  34        0.0000    43.9100    8.8750
  35       17.9700    43.9100   -8.8750
  36       17.9700    43.9100    8.8750
  37       35.9100    43.9100   -8.8750
  38       35.9100    43.9100    8.8750
  39       53.8800    43.9100   -8.8750
  40       53.8800    43.9100    8.8750
  41        0.0000    59.6100   -8.8750
  42        0.0000    59.6100    8.8750
  43       17.9700    59.6100   -8.8750
  44       17.9700    59.6100    8.8750
  45       35.9100    59.6100   -8.8750
  46       35.9100    59.6100    8.8750
  47       53.8800    59.6100   -8.8750
  48       53.8800    59.6100    8.8750
  49        0.0000    74.5100   -8.8750
  50        0.0000    74.5100    8.8750
  51       17.9700    74.5100   -8.8750
  52       17.9700    74.5100    8.8750
  53       35.9100    74.5100   -8.8750
```

Figure 3.4.1d. Input Data File.

54		35.9100		74.5000		8.8750			
55		33.8800		74.5000		-8.8750			
55		33.8800		74.5000		8.8750			
4									
3	2	72							
1.E7		0.3				36.00.		1	2
3846153.85						31000.		1	2
1	1	1	2	1	3	11	9	.2500	
2	1	1	2	2	4	12	10	.2500	
3	1	1	2	3	5	13	11	.2500	
4	1	1	2	4	6	14	12	.2500	
5	1	1	2	5	7	15	13	.2500	
6	1	1	2	6	8	16	14	.2500	
7	1	1	2	9	11	19	17	.2500	
8	1	1	2	10	12	20	18	.2500	
9	1	1	2	11	13	21	19	.2500	
10	1	1	2	12	14	22	20	.2500	
11	1	1	2	13	15	23	21	.2500	
12	1	1	2	14	16	24	22	.2500	
13	1	1	2	19	21	29	27	.2500	
14	1	1	2	20	22	30	28	.2500	
15	1	1	2	21	23	31	29	.2500	
16	1	1	2	22	24	32	30	.2500	
17	1	1	2	25	27	35	33	.2500	
18	1	1	2	26	28	36	34	.2500	
19	1	1	2	27	29	37	35	.2500	
20	1	1	2	28	30	38	36	.2500	
21	1	1	2	29	31	39	37	.2500	
22	1	1	2	30	32	40	38	.2500	
23	1	1	2	33	35	43	41	.2500	
24	1	1	2	34	36	44	42	.2500	
25	1	1	2	35	37	45	43	.2500	
26	1	1	2	36	38	46	44	.2500	
27	1	1	2	37	39	47	45	.2500	
28	1	1	2	38	40	48	46	.2500	
29	1	1	2	41	43	51	49	.2500	
30	1	1	2	42	44	52	50	.2500	
31	1	1	2	43	45	53	51	.2500	
32	1	1	2	44	46	54	52	.2500	
33	1	1	2	45	47	55	53	.2500	
34	1	1	2	46	48	56	54	.2500	
35	3	2	2	9	11	12	10	.1000	
36	3	2	2	11	13	14	12	.1000	
37	3	2	2	13	15	16	14	.1000	
38	3	2	2	17	19	20	18	.1000	
39	3	2	2	19	21	22	20	.1000	
40	3	2	2	21	23	24	22	.1000	
41	3	2	2	25	27	28	26	.1000	
42	3	2	2	27	29	30	28	.1000	
43	3	2	2	29	31	32	30	.1000	
44	3	2	2	33	35	36	34	.1000	
45	3	2	2	35	37	38	36	.1000	
46	3	2	2	37	39	40	38	.1000	
47	3	2	2	41	43	44	42	.1000	
48	3	2	2	43	45	46	44	.1000	
49	3	2	2	45	47	48	46	.1000	
50	3	2	2	1	9	10	2	.1875	
51	3	2	2	9	17	18	10	.1875	
52	3	2	2	25	33	34	26	.1875	
53	3	2	2	33	41	42	34	.1875	
54	3	2	2	41	49	50	42	.1875	
55	3	2	2	3	11	12	4	.1250	
56	3	2	2	11	19	20	12	.1250	
57	3	2	2	19	27	28	20	.1250	
58	3	2	2	27	35	36	28	.1250	
59	3	2	2	35	43	44	36	.1250	

Figure 3.4.1d. (continued).

```
  60   3   2   2      43   51   52   44      .1250
  61   3   2   2       5   13   14    6      .1250
  62   3   2   2      13   21   22   14      .1250
  63   3   2   2      21   29   30   22      .1250
  64   3   2   2      29   37   38   30      .1250
  65   3   2   2      37   45   46   38      .1250
  66   3   2   2      45   53   54   46      .1250
  67   3   2   2       7   15   16    8      .1875
  68   3   2   2      15   23   24   16      .1875
  69   3   2   2      23   31   32   24      .1875
  70   3   2   2      31   39   40   32      .1875
  71   3   2   2      39   47   48   40      .1875
  72   3   2   2      47   55   56   48      .1875
   3
   4   2  36
     1.E7             30000.                      1   2
     1.E7               1.E20
   1   1        9   11     .1500
   2   1       10   12     .1500
   3   1       11   13     .1500
   4   1       12   14     .1500
   5   1       13   15     .1500
   6   1       14   16     .1500
   7   1       17   19     .1500
   8   1       18   20     .1500
   9   1       19   21     .1500
  10   1       20   22     .1500
  11   1       21   23     .1500
  12   1       22   24     .1500
  13   1       25   27     .1500
  14   1       26   28     .1500
  15   1       27   29     .1500
  16   1       28   30     .1500
  17   1       29   31     .1500
  18   1       30   32     .1500
  19   1       33   35     .1500
  20   1       34   36     .1500
  21   1       35   37     .1500
  22   1       36   38     .1500
  23   1       37   39     .1500
  24   1       38   40     .1500
  25   1       41   43     .1500
  26   1       42   44     .1500
  27   1       43   45     .1500
  28   1       44   46     .1500
  29   1       45   47     .1500
  30   1       46   48     .1500
  31   1        1    9    2.6250
  32   1        2   10    2.6250
  33   1        9   17    2.6250
  34   1       10   18    2.6250
  35   1       25   33    2.6250
  36   1       26   34    2.6250
  37   1       33   41    2.6250
  38   1       34   42    2.6250
  39   1       41   49    2.6250
  40   1       42   50    2.6250
  41   1        3   11    1.8750
  42   1        4   12    1.8750
  43   1       11   19    1.8750
  44   1       12   20    1.8750
  45   1       19   27    1.8750
  46   1       20   28    1.8750
  47   1       27   35    1.8750
  48   1       28   36.   1.8750
  49   1       35   43    1.8750
```

Figure 3.4.1d. (continued).

```
1      35   44   1.8750
1      43   51   1.8750
1      44   52   1.8750
1       5   13   1.8750
1       6   14   1.8750
1      13   21   1.8750
1      14   22   1.8750
1      21   29   1.8750
1      22   30   1.8750
1      29   37   1.8750
1      30   38   1.8750
1      37   45   1.8750
1      38   46   1.8750
1      45   53   1.8750
1      46   54   1.8750
1       7   15   2.6250
1       8   16   2.6250
1      15   23   2.6250
1      16   24   2.6250
1      23   31   2.6250
1      24   32   2.6250
1      31   39   2.6250
1      32   40   2.6250
1      39   47   2.6250
1      40   48   2.6250
1      47   55   2.6250
1      48   56   2.6250
2       9   10    .3000
2      11   12    .3000
2      13   14    .3000
2      15   16    .3000
2      17   18    .3000
2      19   20    .3000
2      21   22    .3000
2      23   24    .3000
2      25   26    .3000
2      27   28    .3000
2      29   30    .3000
2      31   32    .3000
2      33   34    .3000
2      35   36    .3000
2      37   38    .3000
2      39   40    .3000
2      41   42    .3000
2      43   44    .3000
2      45   46    .3000
2      47   48    .3000

8   1
2   3

2
1.       0.       20.      1.
2
0.       0.       1.       0.
2   1   25394.
2   1  -25394.
2   1   50662.
2   1  -50662.
2   1   50662.
2   1  -50662.
2   1   25394.
2   1  -25394.
3   1   25[illegible].
```

Figure 3.4.1d. (continued).

```
 50    3    1    2500.
 51    3    1    5000.
 52    3    1    5000.
 53    3    1    5000.
 54    3    1    5000.
 55    3    1    2500.
 56    3    1    2500.
  0
```

Figure 3.4.1d. (continued).

```
REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
          CASE 1

VARIABLE SET CODE                   1
  1 = DISPLACEMENTS U,V,W
  2 = U,V,W + DERIVATIVES
SOLUTION OPTION                     1
  1 = STATIC ANALYSIS
  2 = DYNAMIC ANALYSIS
  3 = NATURAL FREQUENCY
MATERIAL NONLINEARITY FLAG          2
  1 = ELASTIC
  2 = ELASTIC-PLASTIC
GEOMETRIC NONLINEARITY FLAG         2
  1 = SMALL DISPLACEMENT
  2 = LARGE DISPLACEMENT
DYNAMIC SOLUTION OPTION             0
  1 = NEWMARK INTEGRATION
  2 = CENTRAL DIFFERENCE
STIFFNESS REFORMATION INTERVAL      1
MATRIX PROFILE MAP OPTION FLAG      1
WRITE-IN-PLACE FLAG                 0

IMPACT LOADS GENERATOR FLAG         0
  STORAGE ALLOC (1=DEFAULT)         0
USER-DEFINED INCREMENTAL LOADS      0
     = NORMAL LOADS INPUT
     = USER LOADS ROUTINE

POSTPROCESSOR FILE WRITE FLAG       1
  0 = NO OUTPUT
  1 = DATA ON FILE MPOST

NUMBER OF TIME STEP CHANGES         0

NUMBER OF SOLUTION TIME STEPS      20
PRINT FREQUENCY                     1

INITIAL TIME INCREMENT   .10000E+01
INITIAL TIME                0.

TIME INTEGRATION COEFFICIENTS
ALPHA                    .25000E+00
DELTA                    .50000E+00

RAYLEIGH DAMPING COEFFICIENTS
BETA                        0.
GAMMA                       0.
```

Figure 3.4.1e. MAGNA Options Selected.

```
REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
       CASE 1

ITERATION STRATEGY FOR NONLINEAR SOLUTION

  RESIDUAL FORCE CORRECTIONS SWITCHED ON

  ITERATION FLAG ...............     0
       = 0 , NO ITERATION
       = 1 , MODIFIED NEWTON
       = 2 , FULL NEWTON-RAPHSON
       = 3 , COMBINED

  ITERATION FREQUENCY ..........    21
  MAXIMUM ITERATIONS / STEP ....    10

  RESIDUAL FORCE TOLERANCE .....     .100000E+00
  DISPLACEMENT TOLERANCE .......     .500000E-03
```

Figure 3.4.1e. (continued).

REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
CASE 1

NODAL COORDINATES

NODE	X	Y	Z
1	0.00000	0.00000	-8.87500
2	0.00000	0.00000	8.87500
3	17.97000	0.00000	-8.87500
4	17.97000	0.00000	8.87500
5	35.91000	0.00000	-8.87500
6	35.91000	0.00000	8.87500
7	53.88000	0.00000	-8.87500
8	53.88000	0.00000	8.87500
9	0.00000	9.30000	-8.87500
10	0.00000	9.30000	8.87500
11	17.97000	9.30000	-8.87500
12	17.97000	9.30000	8.87500
13	35.91000	9.30000	-8.87500
14	35.91000	9.30000	8.87500
15	53.88000	9.30000	-8.87500
16	53.88000	9.30000	8.87500
17	0.00000	18.60000	-8.87500
18	0.00000	18.60000	8.87500
19	17.97000	18.60000	-8.87500
20	17.97000	18.60000	8.87500
21	35.91000	18.60000	-8.87500
22	35.91000	18.60000	8.87500
23	53.88000	18.60000	-8.87500
24	53.88000	18.60000	8.87500
25	0.00000	31.20000	-8.87500
26	0.00000	31.20000	8.87500
27	17.97000	31.20000	-8.87500
28	17.97000	31.20000	8.87500
29	35.91000	31.20000	-8.87500
30	35.91000	31.20000	8.87500
31	53.88000	31.20000	-8.87500
32	53.88000	31.20000	8.87500
33	0.00000	43.90000	-8.87500
34	0.00000	43.90000	8.87500
35	17.97000	43.90000	-8.87500
36	17.97000	43.90000	8.87500
37	35.91000	43.90000	-8.87500
38	35.91000	43.90000	8.87500
39	53.88000	43.90000	-8.87500
40	53.88000	43.90000	8.87500
41	0.00000	59.60000	-8.87500
42	0.00000	59.60000	8.87500
43	17.97000	59.60000	-8.87500
44	17.97000	59.60000	8.87500
45	35.91000	59.60000	-8.87500
46	35.91000	59.60000	8.87500
47	53.88000	59.60000	-8.87500
48	53.88000	59.60000	8.87500
49	0.00000	74.50000	-8.87500
50	0.00000	74.50000	8.87500
51	17.97000	74.50000	-8.87500

Figure 3.4.1f. Nodal Coordinates.

52	17.97000	74.50000	8.87500
53	35.91000	74.50000	-8.87500
54	35.91000	74.50000	8.87500
55	53.88000	74.50000	-8.87500
56	53.88000	74.50000	8.87500

Figure 3.4.1f. (continued).

INPUT FOR ELEMENT TYPE 3   TWO-DIMENSIONAL PLANE STRESS, PLANE STRAIN AND SHEAR WEB ELEMENTS

MATERIAL PROPERTIES

MAT.	MODULUS	POISSON RATIO	DENSITY	YIELD	MX.INC.STRAIN	GAMMA	HARDENING	S-E CURVE
1	.1000E+08	.300000	0.000000	.3000E+05	.2000E-03	0.0000	ISOTROPIC	2
2	.30462E+07	0.000000	1.000000	.3600E+05	.2000E-03	0.0000	ISOTROPIC	2

ELEMENT CONNECTIVITY   TWO-DIMENSIONAL ELEMENTS

ITYPE =1 : PLANE STRESS ELEMENTS
ITYPE =2 : PLANE STRAIN ELEMENTS
ITYPE =3 : SHEAR PANEL ELEMENTS

ELEM	ITYPE	MATL	INT	KGEN	NODE1	NODE2	NODE3	NODE4	THICKNESS	BEND.FLAG
1	1	1	2	0	1	3	11	9	.2500	0
2	1	1	2	0	2	4	12	10	.2500	0
3	1	1	2	0	3	5	13	11	.2500	0
4	1	1	2	0	4	6	14	12	.2500	0
5	1	1	2	0	5	7	15	13	.2500	0
6	1	1	2	0	6	8	16	14	.2500	0
7	1	1	2	0	9	11	19	17	.2500	0
8	1	1	2	0	10	12	20	18	.2500	0
9	1	1	2	0	11	13	21	19	.2500	0
10	1	1	2	0	12	14	22	20	.2500	0
11	1	1	2	0	13	15	23	21	.2500	0
12	1	1	2	0	14	16	24	22	.2500	0
13	1	1	2	0	19	21	29	27	.2500	0
14	1	1	2	0	20	22	30	28	.2500	0
15	1	1	2	0	21	23	31	29	.2500	0
16	1	1	2	0	22	24	32	30	.2500	0
17	1	1	2	0	25	27	35	33	.2500	0
18	1	1	2	0	26	28	36	34	.2500	0
19	1	1	2	0	27	29	37	35	.2500	0
20	1	1	2	0	28	30	38	36	.2500	0
21	1	1	2	0	29	31	39	37	.2500	0
22	1	1	2	0	30	32	40	38	.2500	0
23	1	1	2	0	33	35	43	41	.2500	0
24	1	1	2	0	34	36	44	42	.2500	0
25	1	1	2	0	35	37	45	43	.2500	0
26	1	1	2	0	36	38	46	44	.2500	0
27	1	1	2	0	37	39	47	45	.2500	0
28	1	1	2	0	38	40	48	46	.2500	0
29	1	1	2	0	41	43	51	49	.2500	0
30	1	1	2	0	42	44	52	50	.2500	0
31	1	1	2	0	43	45	53	51	.2500	0
32	1	1	2	0	44	46	54	52	.2500	0
33	1	1	2	0	45	47	55	53	.2500	0
34	1	1	2	0	46	48	56	54	.2500	0
35	3	2	2	0	9	11	12	10	.1000	0
36	3	2	2	0	11	13	14	12	.1000	0
37	3	2	2	0	13	15	16	14	.1000	0
38	3	2	2	0	17	19	20	18	.1000	0
39	3	2	2	0	19	21	22	20	.1000	0
40	3	2	2	0	21	23	24	22	.1000	0
41	3	2	2	0	25	27	28	26	.1000	0
42	3	2	2	0	27	29	30	28	.1000	0
43	3	2	2	0	29	31	32	30	.1000	0
44	3	2	2	0	33	35	36	34	.1000	0

Figure 3.4.1g. Element Connectivities.

AD-A096 594 DAYTON UNIV OH RESEARCH INST F/G 1/3
STRUCTURAL FLIGHT LOADS SIMULATION CAPABILITY. VOLUME II. STRUC--ETC(U)
NOV 80 T S BRUNER, M P BOUCHARD, J G GEBARA F33615-76-C-3135
UNCLASSIFIED UDR-TR-80-73-VOL-2 AFWAL-TR-3118-VOL-2 NL

3 OF 4
AD A096594

45	3	2	2	0	35	37	38	36	.1000	0
46	3	2	2	0	37	39	40	38	.1000	0
47	3	2	2	0	41	43	44	42	.1000	0
48	3	2	2	0	43	45	46	44	.1000	0
49	3	2	2	0	45	47	48	46	.1000	0
50	3	2	2	0	1	9	10	2	.1875	0
51	3	2	2	0	9	17	18	10	.1875	0
52	3	2	2	0	25	33	34	26	.1875	0
53	3	2	2	0	33	41	42	34	.1875	0
54	3	2	2	0	41	49	50	42	.1875	0
55	3	2	2	0	3	11	12	4	.1250	0
56	3	2	2	0	11	19	20	12	.1250	0
57	3	2	2	0	19	27	28	20	.1250	0
58	3	2	2	0	27	35	36	28	.1250	0
59	3	2	2	0	35	43	44	36	.1250	0
60	3	2	2	0	43	51	52	44	.1250	0
61	3	2	2	0	5	13	14	6	.1250	0
62	3	2	2	0	13	21	22	14	.1250	0
63	3	2	2	0	21	29	30	22	.1250	0
64	3	2	2	0	29	37	38	30	.1250	0
65	3	2	2	0	37	45	46	38	.1250	0
66	3	2	2	0	45	53	54	46	.1250	0
67	3	2	2	0	7	15	16	8	.1875	0
68	3	2	2	0	15	23	24	16	.1875	0
69	3	2	2	0	23	31	32	24	.1875	0
70	3	2	2	0	31	39	40	32	.1875	0
71	3	2	2	0	39	47	48	40	.1875	0
72	3	2	2	0	47	55	56	48	.1875	0

Figure 3.4.1g. (continued).

INPUT FOR ELEMENT TYPE 4   THREE-DIMENSIONAL TRUSS ELEMENTS

MATERIAL PROPERTIES

MAT.	MODULUS	DENSITY	YIELD	MX.INC.STRAIN	GAMMA	HARDENING	S-E CURVE
1	.1000E+08	0.000000	.3000E+05	.2000E-03	0.0000	ISOTROPIC	2
2	.1000E+20	0.000000	.1000E+21	.2000E-03	0.0000	ISOTROPIC	1

ELEMENT CONNECTIVITY   THREE-DIMENSIONAL TRUSS ELEMENTS

ELEM	MATL	KGEN	NODE-1	NODE-2	AREA
1	1	0	9	11	.15000
2	1	0	10	12	.15000
3	1	0	11	13	.15000
4	1	0	12	14	.15000
5	1	0	13	15	.15000
6	1	0	14	16	.15000
7	1	0	17	19	.15000
8	1	0	18	20	.15000
9	1	0	19	21	.15000
10	1	0	20	22	.15000
11	1	0	21	23	.15000
12	1	0	22	24	.15000
13	1	0	25	27	.15000
14	1	0	26	28	.15000
15	1	0	27	29	.15000
16	1	0	28	30	.15000
17	1	0	29	31	.15000
18	1	0	30	32	.15000
19	1	0	33	35	.15000
20	1	0	34	36	.15000
21	1	0	35	37	.15000
22	1	0	36	38	.15000
23	1	0	37	39	.15000
24	1	0	38	40	.15000
25	1	0	41	43	.15000
26	1	0	42	44	.15000
27	1	0	43	45	.15000
28	1	0	44	46	.15000
29	1	0	45	47	.15000
30	1	0	46	48	.15000
31	1	0	1	9	2.62500
32	1	0	2	10	2.62500
33	1	0	9	17	2.62500
34	1	0	10	18	2.62500
35	1	0	25	33	2.62500
36	1	0	26	34	2.62500
37	1	0	33	41	2.62500
38	1	0	34	42	2.62500
39	1	0	41	49	2.62500
40	1	0	42	50	2.62500
41	1	0	3	11	1.87500
42	1	0	4	12	1.87500
43	1	0	11	19	1.87500
44	1	0	12	20	1.87500
45	1	0	19	27	1.87500
46	1	0	20	28	1.87500
47	1	0	27	35	1.87500
48	1	0	28	36	1.87500

Figure 3.4.1g. (continued).

49	1	0	35	43	1.87500
50	1	0	36	44	1.87500
51	1	0	43	51	1.87500
52	1	0	44	52	1.87500
53	1	0	5	13	1.87500
54	1	0	6	14	1.87500
55	1	0	13	21	1.87500
56	1	0	14	22	1.87500
57	1	0	21	29	1.87500
58	1	0	22	30	1.87500
59	1	0	29	37	1.87500
60	1	0	30	38	1.87500
61	1	0	37	45	1.87500
62	1	0	38	46	1.87500
63	1	0	45	53	1.87500
64	1	0	46	54	1.87500
65	1	0	7	15	2.62500
66	1	0	8	16	2.62500
67	1	0	15	23	2.62500
68	1	0	16	24	2.62500
69	1	0	23	31	2.62500
70	1	0	24	32	2.62500
71	1	0	31	39	2.62500
72	1	0	32	40	2.62500
73	1	0	39	47	2.62500
74	1	0	40	48	2.62500
75	1	0	47	55	2.62500
76	1	0	48	56	2.62500
77	2	0	9	10	.30000
78	2	0	11	12	.30000
79	2	0	13	14	.30000
80	2	0	15	16	.30000
81	2	0	17	18	.30000
82	2	0	19	20	.30000
83	2	0	21	22	.30000
84	2	0	23	24	.30000
85	2	0	25	26	.30000
86	2	0	27	28	.30000
87	2	0	29	30	.30000
88	2	0	31	32	.30000
89	2	0	33	34	.30000
90	2	0	35	36	.30000
91	2	0	37	38	.30000
92	2	0	39	40	.30000
93	2	0	41	42	.30000
94	2	0	43	44	.30000
95	2	0	45	46	.30000
96	2	0	47	48	.30000

Figure 3.4.1g. (concluded).

```
REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
      CASE 1

BOUNDARY CONDITIONS

DEGREES OF FREEDOM PER NODE.....        3
UNCONSTRAINED NODAL CODE........        7
MAXIMUM PACKING CODE (MAXKOD)...        4

NUMBER OF TYPE 1 CONSTRAINTS....        1
NUMBER OF TYPE 2 CONSTRAINTS....        4
NUMBER OF TYPE 3 CONSTRAINTS....        0
NUMBER OF LINEAR CONSTRAINTS....        0
MAX NUMBER TERMS/CONSTRAINT.....        0

TYPE 1 CONSTRAINTS

NODE    1  THRU    8  BY   1    COMPONENTS    1    2    3    0    0    0    0    0    0    0
```

Figure 3.4.1h. Boundary Conditions.

REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
CASE 1

NODAL VARIABLE TABLES

NODE	NFDF	CODE	1	2	3
1	1	0	0	0	0
2	1	0	0	0	0
3	1	0	0	0	0
4	1	0	0	0	0
5	1	0	0	0	0
6	1	0	0	0	0
7	1	0	0	0	0
8	1	0	0	0	0
9	1	7	1	2	3
10	4	7	4	5	6
11	7	7	7	8	9
12	10	7	10	11	12
13	13	7	13	14	15
14	16	7	16	17	18
15	19	7	19	20	21
16	22	7	22	23	24
17	25	7	25	26	27
18	28	7	28	29	30
19	31	7	31	32	33
20	34	7	34	35	36
21	37	7	37	38	39
22	40	7	40	41	42
23	43	7	43	44	45
24	46	7	46	47	48
25	49	7	49	50	51
26	52	7	52	53	54
27	55	7	55	56	57
28	58	7	58	59	60
29	61	7	61	62	63
30	64	7	64	65	66
31	67	7	67	68	69
32	70	7	70	71	72
33	73	7	73	74	75
34	76	7	76	77	78
35	79	7	79	80	81
36	82	7	82	83	84
37	85	7	85	86	87
38	88	7	88	89	90
39	91	7	91	92	93
40	94	7	94	95	96
41	97	7	97	98	99
42	100	7	100	101	102
43	103	7	103	104	105
44	106	7	106	107	108
45	109	7	109	110	111
46	112	7	112	113	114
47	115	7	115	116	117
48	118	7	118	119	120
49	121	7	121	122	123
50	124	7	124	125	126
51	127	7	127	128	129
52	130	7	130	131	132
53	133	7	133	134	135

Figure 3.4.1h. (continued).

```
54  136     7    136  137  138
55  139     7    139  140  141
56  142     7    142  143  144

REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
     CASE 1


MATRIX PARTITIONING DATA :

DEGREES OF FREEDOM . . . . .      144
NUMBER OF PARTITIONS . . .          2
MAXIMUM PARTITION SIZE . .       3661
WORK AREA AVAILABLE  . . .      12180
WORK AREA USED . . . . . .       7466

MAXIMUM HALF-BANDWIDTH . .         33
AVERAGE HALF-BANDWIDTH . .         26
APPARENT POPULATION  . .         3726
```

Figure 3.4.1h. (continued).

```
REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
      CASE 1

MATRIX PROFILE MAP

  1/ X
  2/ XX
  3/ XXX
  4/ XXXX
  5/ XXXXX
  6/ XXXXXX
  7/    XXXX
  8/    XXXXX
  9/    XXXXXX
 10/       XXXX
 11/       XXXXX
 12/       XXXXXX
 13/ XXXXXXXXXXXXX
 14/ XXXXXXXXXXXXXX
 15/ XXXXXXXXXXXXXXX
 16/ XXXXXXXXXXXXXXXX
 17/ XXXXXXXXXXXXXXXXX
 18/  XXXXXXXXXXXXXXXXX
 19/    XXXXXXXXXXXXXXXX
 20/    XXXXXXXXXXXXXXXXX
 21/     XXXXXXXXXXXXXXXXX
 22/       XXXXXXXXXXXXXXXX
 23/       XXXXXXXXXXXXXXXXX
 24/        XXXXXXXXXXXXXXXXX
 25/                         X
 26/                         XX
 27/                         XXX
 28/                XXXXXXXXXXXXX
 29/                XXXXXXXXXXXXXX
 30/                XXXXXXXXXXXXXXX
 31/                XXXXXXXXXXXXXXXX
 32/                XXXXXXXXXXXXXXXXX
 33/                 XXXXXXXXXXXXXXXXX
 34/                   XXXXXXXXXXXXXXXX
 35/                   XXXXXXXXXXXXXXXXX
 36/                    XXXXXXXXXXXXXXXXX
 37/                         XXXXXXXXXXXXX
 38/                         XXXXXXXXXXXXXX
 39/                         XXXXXXXXXXXXXXX
 40/                         XXXXXXXXXXXXXXXX
 41/                         XXXXXXXXXXXXXXXXX
 42/                          XXXXXXXXXXXXXXXXX
 43/                            XXXXXXXXXXXXXXXX
 44/                            XXXXXXXXXXXXXXXXX
 45/                             XXXXXXXXXXXXXXXXX
 46/                               XXXXXXXXXXXXXXXX
 47/                               XXXXXXXXXXXXXXXXX
 48/                                XXXXXXXXXXXXXXXXX
 49/                                     XXXXXXXXXXXXX
 50/                                     XXXXXXXXXXXXXX
 51/                                     XXXXXXXXXXXXXXX
 52/                                     XXXXXXXXXXXXXXXX
```

Figure 3.4.1h. (continued).

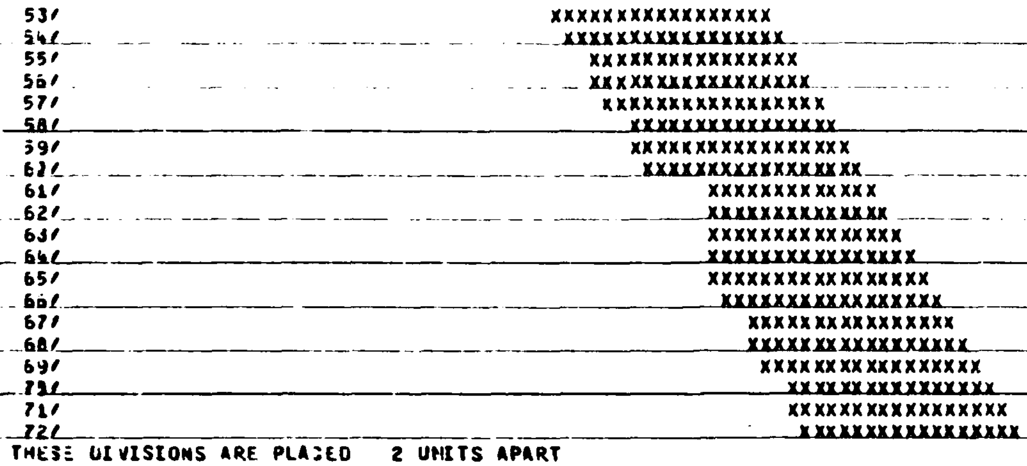


Figure 3.4.1h. (continued).

REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
CASE 1

SUMMARY OF INPUT DATA CURVES FOR NONLINEAR AND DYNAMIC ANALYSIS

DATA CURVE 1 POINTS 2

PT	X	F(X)
1	0.	0.
2	.21000E+02	.10000E+01

DATA CURVE 2 POINTS 2

PT	X	F(X)
1	0.	0.
2	.10000E+11	0.

Figure 3.4.1i. Stress/Strain Curves.

DIRECT NODAL LOADS INPUT

NODE	COMPT	DOF	LOAD CURVE	MULTIPLIER
49	2	122	1	25394.000000
50	2	125	1	-25394.000000
51	2	128	1	50662.000000
52	2	131	1	-50662.000000
53	2	134	1	50662.000000
54	2	137	1	-50662.000000
55	2	140	1	25394.000000
56	2	143	1	-25394.000000
49	3	123	1	2500.000000
50	3	126	1	2500.000000
51	3	129	1	5000.000000
52	3	132	1	5000.000000
53	3	135	1	5000.000000
54	3	138	1	5000.000000
55	3	141	1	2500.000000
56	3	144	1	2500.000000

Figure 3.4.1j. Loads Data.

```
REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
      CASE 11

ITERATION CONTROL VARIABLES   INCREMENT =     1   TIME =   .100000E+01

NUMIT =   0    FNORM = 0.          DNORM = 0.
               STIFFNESS TO BE REFORMED
               NEXT ITERATION TO BE ACCEPTED
```

Figure 3.4.1j. (continued).

REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
CASE 1

NODAL LOADS FOR TIME = .10000E+01

NODE	COMPT	DOF	MAGNITUDE
49	2	122	1269.73000
50	2	125	-1269.73000
51	2	128	2533.10000
52	2	131	-2533.10000
53	2	134	2533.10000
54	2	137	-2533.10000
55	2	140	1269.73000
56	2	143	-1269.73000
49	3	123	125.00000
50	3	126	125.00000
51	3	129	250.00000
52	3	132	250.00000
53	3	135	250.00000
54	3	138	250.00000
55	3	141	125.00000
56	3	144	125.00000

Figure 3.4.1j. (continued).

REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
CASE 1

LOAD CASE 1
DISPLACEMENTS (TOTAL) AT INCREMENT 1 TIME = 1.00000E+00

NODE	-- U --	-- V --	-- W --
1	0.00000000 *	0.00000000 *	0.00000000 *
2	0.00000000 *	0.00000000 *	0.00000000 *
3	0.00000000 *	0.00000000 *	0.00000000 *
4	0.00000000 *	0.00000000 *	0.00000000 *
5	0.00000000 *	0.00000000 *	0.00000000 *
6	0.00000000 *	0.00000000 *	0.00000000 *
7	0.00000000 *	0.00000000 *	0.00000000 *
8	0.00000000 *	0.00000000 *	0.00000000 *
9	.00028596	.00007253	.00035019
10	-.00028596	-.00007253	.00035019
11	.00013114	.00060835	.00071929
12	-.00013114	-.00060835	.00071929
13	-.00011558	.00067849	.00084554
14	.00011558	-.00067849	.00084554
15	-.00040477	.00070739	.00055451
16	.00040477	-.00070739	.00055451
17	.00009335	.00001940	.00072605
18	-.00009335	-.00001940	.00072605
19	.00003122	.00127869	.00203943
20	-.00003122	-.00127869	.00203943
21	-.00028957	.00136873	.00235643
22	.00028957	-.00136873	.00235643
23	-.00055667	.00134894	.00188087
24	.00055667	-.00134894	.00188087
25	-.00044255	.00445083	.00542775
26	.00044255	-.00445083	.00542775
27	-.00027624	.00262222	.00559928
28	.00027624	-.00262222	.00559928
29	-.00043712	.00216637	.00557064
30	.00043712	-.00216637	.00557064
31	-.00067322	.00211134	.00481664
32	.00067322	-.00211134	.00481664
33	.00009504	.00443836	.01144897
34	-.00009504	-.00443836	.01144897
35	-.00013640	.00345740	.01086256
36	.00013640	-.00345740	.01086256
37	-.00046363	.00293242	.01010861
38	.00046363	-.00293242	.01010861
39	-.00072766	.00273156	.00890676
40	.00072766	-.00273156	.00890676
41	.00019712	.00475122	.01941194
42	-.00019712	-.00475122	.01941194
43	-.00003607	.00428956	.01856144
44	.00003607	-.00428956	.01856144
45	-.00038097	.00376320	.01702472
46	.00038097	-.00376320	.01702472
47	-.00052080	.00327923	.01500001
48	.00052080	-.00327923	.01500001
49	.00044394	.00512953	.02799721
50	-.00044394	-.00512953	.02799721

Figure 3.4.1k. Node Displacement.

51	.00029420	.00494427	.02718483
52	-.00029420	-.00494427	.02718483
53	.00010572	.00443082	.02477610
54	-.00010572	-.00443082	.02477610
55	-.00866389	.00365262	.02110907
55	.00866389	-.00365262	.02110907

Figure 3.4.1k. (continued).

REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
CASE 1

TWO-DIMENSIONAL ELEMENT STRESSES (4-NODE PLANE STRESS PLANE STRAIN AND SHEAR PANEL ELEMENTS) INCREMENT 1

ELEM	INTPT	EXX / SXX	EYY / SYY	EXY / SXY	EPX / SMAX	EPY / SMIN	EPXY / YLDF	FR / SEQ
1	1	-.1855809E-05	.1997563E-04	.3378604E-04	0.	0.	0.	0.
		.4546023E+02	.2133944E+03	.1293461E+03	.2041415E+03	-.2528685E+02	-.8999114E+09	.2975917E+03
1	2	-.6925656E-05	.1997563E-04	.5108187E-04	0.	0.	0.	0.
		-.1425238E+12	.1966806E+03	.1361614E+03	.3149898E+03	-.1285616E+03	-.8998438E+09	.3952749E+03
1	3	-.1855809E-05	.5324201E-04	.2398930E-04	0.	0.	0.	0.
		.1551296E+03	.5789590E+03	.9226652E+02	.5981740E+03	.1359146E+03	-.8997050E+09	.5431246E+03
1	4	-.6925656E-05	.5324201E-04	.4120607E-04	0.	0.	0.	0.
		.9941706E+12	.5622452E+03	.1584849E+03	.6113127E+03	.5034940E+02	-.8996545E+09	.5077576E+03
2	1	.1855871E-05	-.1997236E-04	-.3378545E-04	0.	0.	0.	0.
		-.4544875E+02	-.2133582E+03	-.1293440E+03	.2530223E+02	-.2041091E+03	-.8999115E+09	.2975601E+03
2	2	.6926520E-05	-.1997236E-04	-.5099982E-04	0.	0.	0.	0.
		.1027267E+12	-.1966418E+03	-.1361532E+03	.1205799E+03	-.3149490E+03	-.8998438E+09	.3952498E+03
2	3	.1855871E-05	-.5323411E-04	-.2398809E-04	0.	0.	0.	0.
		-.1551029E+13	-.5788719E+03	-.9226189E+02	-.1358872E+03	-.5980876E+03	-.8997051E+09	.5430485E+03
2	4	.6926520E-05	-.5323411E-04	-.4120157E-04	0.	0.	0.	0.
		-.9930146E+12	-.5621555E+03	-.1584676E+03	-.5031897E+02	-.6112100E+03	-.8996546E+09	.5076764E+03
3	1	-.2906287E-05	.6701285E-04	.9321596E-05	0.	0.	0.	0.
		.1889843E+03	.7260238E+03	.3585229E+02	.7292432E+03	.1066049E+03	-.8995695E+09	.6561142E+03
3	2	-.1084635E-04	.6701285E-04	.1157928E-04	0.	0.	0.	0.
		.1017300E+13	.7006470E+03	.4453560E+02	.7039413E+03	.9843723E+02	-.8995641E+09	.6602494E+03
3	3	-.2906287E-05	.7136815E-04	-.5995128E-05	0.	0.	0.	0.
		.2033424E+13	.7746842E+03	-.2345818E+02	.7756133E+03	.2024133E+03	-.8995144E+09	.6968161E+03
3	4	-.1084635E-04	.7136815E-04	-.3737284E-05	0.	0.	0.	0.
		.1160889E+13	.7485082E+03	-.1437417E+02	.7488347E+03	.1157624E+03	-.8995125E+09	.6981887E+03
4	1	.2906298E-05	-.6700186E-04	-.9321296E-05	0.	0.	0.	0.
		-.1889479E+03	-.7267029E+03	-.3585114E+02	-.1065603E+03	-.7290825E+03	-.8995697E+09	.6560071E+03
4	2	.1084651E-04	-.6700186E-04	-.1157816E-04	0.	0.	0.	0.
		-.1016920E+03	-.7005264E+03	-.4453137E+02	-.9839942E+02	-.7038198E+03	-.8995642E+09	.6601434E+03
4	3	.2906298E-05	-.7135526E-04	.5995547E-05	0.	0.	0.	0.
		-.2032998E+13	-.7745425E+03	.2305980E+02	-.2023704E+03	-.7754719E+03	-.8995146E+09	.6966906E+03
4	4	.1084651E-04	-.7135526E-04	.3738849E-05	0.	0.	0.	0.
		-.1160447E+13	-.7483660E+03	.1438019E+02	-.1157178E+03	-.7486928E+03	-.8995127E+09	.6980648E+03
5	1	-.3400795E-05	.7361866E-04	-.1865345E-04	0.	0.	0.	0.
		.2053275E+13	.7977849E+03	-.7176713E+02	.8063544E+03	.1967580E+03	-.8994697E+09	.7281926E+03
5	2	-.1269182E-04	.7361866E-04	-.1773146E-04	0.	0.	0.	0.
		.1032283E+03	.7671551E+03	-.6819791E+02	.7740880E+03	.9629549E+02	-.8994661E+09	.7307146E+03
5	3	-.3400795E-05	.7541212E-04	-.3661228E-04	0.	0.	0.	0.
		.2112400E+13	.8174932E+03	-.1408165E+03	.8486046E+03	.1801286E+03	-.8994403E+09	.7744146E+03
5	4	-.1269182E-04	.7541212E-04	-.3568395E-04	0.	0.	0.	0.
		.1091408E+03	.7868634E+03	-.1372460E+03	.8136022E+03	.8240201E+02	-.8993983E+09	.7756908E+03

Figure 3.4.11. Element Stresses.

REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
CASE 1

TWO-DIMENSIONAL ELEMENT STRESSES (4-NODE PLANE STRESS PLANE STRAIN AND SHEAR PANEL ELEMENTS) INCREMENT 1

ELEM	INTPT	EXX / SXX	EYY / SYY	EXY / SXY	EPX / SMAX	EPY / SMIN	EPXY / YLDF	FR / SEQ
5	1	.3400819E-05	-.7366578E-04	.1365906E-04	0.	0.	0.	0.
		-.2052848E+03	-.7976432E+03	.7176566E+02	-.1967142E+03	-.8062138E+03	-.8994693E+09	.7280683E+03
5	2	.1269215E-04	-.7360578E-04	.1772997E-04	0.	0.	0.	0.
		-.1031623E+03	-.7670124E+03	.6819226E+02	-.9624958E+02	-.7739451E+03	-.8994662E+09	.73.59.3E+03
5	3	.3401819E-05	-.7540068E-04	.3661213E-04	0.	0.	0.	0.
		-.2112[illegible]2E+03	-.8173674E+03	.1448159E+03	-.1800868E+03	-.8484626E+03	-.8994004E+09	.7743084E+03
5	4	.1269215E-04	-.7540068E-04	.3568339E-04	0.	0.	0.	0.
		-.1096995E+03	-.7867367E+03	.1372438E+03	-.8235840E+02	-.8134778E+03	-.8993985E+09	.7755851E+03
7	1	-.7655431E-05	.1072887E-04	.1346929E-04	0.	0.	0.	0.
		-.4875572E+02	.9266197E+02	.7488188E+02	.1249436E+03	-.8103735E+02	-.8999677E+09	.1737315E+03
7	2	-.4578679E-05	.1072887E-04	.4271588E-04	0.	0.	0.	0.
		-.1494525E+02	.1128051E+03	.1642888E+03	.2184495E+03	-.1305897E+03	-.8999067E+09	.3054523E+03
7	3	-.7655431E-05	.5564848E-04	.2541295E-04	0.	0.	0.	0.
		.9933091E+02	.5862841E+03	.9774211E+02	.6051705E+03	.8344445E+02	-.8996760E+09	.5692276E+03
7	4	-.4578679E-05	.5564848E-04	.4566158E-04	0.	0.	0.	0.
		.1331414E+03	.5964272E+03	.1871599E+03	.6625884E+03	.6698424E+02	-.8996009E+09	.6317669E+03
8	1	.7657964E-05	-.1072457E-04	-.1346426E-04	0.	0.	0.	0.
		.4879768E+02	-.9261539E+02	-.7486255E+02	.8146738E+02	-.1248761E+03	-.8999677E+09	.1796923E+03
8	2	.4586332E-05	-.1072457E-04	-.4270592E-04	0.	0.	0.	0.
		.1504353E+02	-.1027326E+03	-.1642535E+03	.1306462E+03	-.2183353E+03	-.8999467E+09	.3953906E+03
8	3	.7657960E-05	-.5563370E-04	-.2540386E-04	0.	0.	0.	0.
		-.9924450E+02	-.5660803E+03	-.9769562E+02	-.8037114E+02	-.6049537E+03	-.8996762E+09	.5630410E+03
8	4	.4586332E-05	-.5563070E-04	-.4863967E-04	0.	0.	0.	0.
		-.1329987E+03	-.5962466E+03	-.1873757E+03	-.6688177E+02	-.6623235E+03	-.8996012E+09	.6315443E+03
9	1	-.1461335E-04	.7254409E-04	-.8258819E-05	0.	0.	0.	0.
		.7857[illegible]E+02	.7490119E+03	-.3176469E+02	.7505136E+03	.7766650E+02	-.8994886E+09	.7151068E+03
9	2	-.1696494E-04	.7254409E-04	-.7517916E-05	0.	0.	0.	0.
		.5272849E+02	.7412595E+03	-.2329965E+02	.7425640E+03	.5148392E+02	-.8994843E+09	.7181475E+03
9	3	-.1461335E-04	.7378051E-04	-.1279515E-04	0.	0.	0.	0.
		.8264620E+02	.7625989E+03	-.4321211E+02	.7661422E+03	.7910290E+02	-.8994674E+09	.7298131E+03
9	4	-.1696494E-04	.7376051E-04	-.1215415E-04	0.	0.	0.	0.
		.5680459E+02	.7548465E+03	-.4674675E+02	.7579631E+03	.5368795E+02	-.8994633E+09	.7325960E+03
10	1	.1461366E-04	-.7251728E-04	.8262499E-05	0.	0.	0.	0.
		-.7847622E+02	-.7487162E+03	.3177884E+02	-.7697483E+02	-.7502196E+03	-.8994898E+09	.7143473E+03
10	2	.1696548E-04	-.7251728E-04	.7523537E-05	0.	0.	0.	0.
		-.5263416E+02	-.7419630E+03	.2332130E+02	-.5138730E+02	-.7422098E+03	-.8994846E+09	.7178968E+03
10	3	.1461366E-04	-.7374978E-04	.1279319E-04	0.	0.	0.	0.
		-.8254140E+02	-.7622602E+03	.4322766E+02	-.7899467E+02	-.7658669E+03	-.8994678E+09	.7295243E+03
10	4	.1696546E-04	-.7374978E-04	.1216031E-04	0.	0.	0.	0.
		-.5669724E+02	-.7545469E+03	.4677043E+02	-.5357643E+02	-.7576277E+03	-.8994637E+09	.7323189E+03
11	1	-.1584449E-04	.7312559E-04	-.1708891E-04	0.	0.	0.	0.
		.6696136E+02	.7513543E+03	-.6572656E+02	.7576[illegible]3E+03	.6070639E+02	-.8994683E+09	.7231539E+03

Figure 3.4.11. (continued).

REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
CASE 1

THREE-DIMENSIONAL BAR ELEMENT STRESSES (ELEMENT TYPE 4) INCREMENT 1

ELEMENT	AREA	LENGTH	STRAIN	PLASTIC STRAIN	STRESS	FORCE	Y.S.SIZE	Y.S.TRANSL
1	.15000	17.97000	-.8781234E-05	0.	-.8781234E+02	-.1317185E+02	.300E+05	0.
2	.15000	17.97000	.8782622E-05	0.	.8782622E+02	.1317393E+02	.300E+05	0.
3	.15000	17.94000	-.1375260E-04	0.	-.1375260E+03	-.2062889E+02	.300E+05	0.
4	.15000	17.94000	.1375285E-04	0.	.1375285E+03	.2062928E+02	.300E+05	0.
5	.15000	17.97000	-.1609253E-04	0.	-.1609253E+03	-.2413880E+02	.300E+05	0.
6	.15000	17.97000	.1609305E-04	0.	.1609305E+03	.2413958E+02	.300E+05	0.
7	.15000	17.97000	-.3452141E-05	0.	-.3452141E+02	-.5178212E+01	.300E+05	0.
8	.15000	17.97000	.3462406E-05	0.	.3462406E+02	.5193609E+01	.300E+05	0.
9	.15000	17.94000	-.1782566E-04	0.	-.1782566E+03	-.2673850E+02	.300E+05	0.
10	.15000	17.94000	.1782632E-04	0.	.1782632E+03	.2673948E+02	.300E+05	0.
11	.15000	17.97000	-.1491876E-04	0.	-.1491876E+03	-.2237814E+02	.300E+05	0.
12	.15000	17.97000	.1491968E-04	0.	.1491968E+03	.2237953E+02	.300E+05	0.
13	.15000	17.97000	.9260413E-05	0.	.9260413E+02	.1389062E+02	.300E+05	0.
14	.15000	17.97000	-.9249882E-05	0.	-.9249882E+02	-.1387482E+02	.300E+05	0.
15	.15000	17.94000	-.8967335E-05	0.	-.8967335E+02	-.1345100E+02	.300E+05	0.
16	.15000	17.94000	.8968064E-05	0.	.8968064E+02	.1345210E+02	.300E+05	0.
17	.15000	17.97000	-.1347185E-04	0.	-.1347185E+03	-.2020777E+02	.300E+05	0.
18	.15000	17.97000	.1347380E-04	0.	.1347380E+03	.2021070E+02	.300E+05	0.
19	.15000	17.97000	-.1287672E-04	0.	-.1287672E+03	-.1931507E+02	.300E+05	0.
20	.15000	17.97000	.1288093E-04	0.	.1288093E+03	.1932139E+02	.300E+05	0.
21	.15000	17.94000	-.1857333E-04	0.	-.1857333E+03	-.2786000E+02	.300E+05	0.
22	.15000	17.94000	.1857630E-04	0.	.1857630E+03	.2786445E+02	.300E+05	0.

Figure 3.4.11. (continued).

REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
CASE 1

THREE-DIMENSIONAL BAR ELEMENT STRESSES (ELEMENT TYPE 4) INCREMENT 1

ELEMENT	AREA	LENGTH	STRAIN	PLASTIC STRAIN	STRESS	FORCE	Y.S.SIZE	Y.S.TRANSL
23	.15000	17.97000	-.1435671E-04	0.	-.1435671E+03	-.2153507E+02	.300E+05	0.
24	.15000	17.97000	.1436152E-04	0.	.1436152E+03	.2154227E+02	.300E+05	0.
25	.15000	17.97000	-.1301942E-04	0.	-.1301942E+03	-.1952913E+02	.300E+05	0.
26	.15000	17.97000	.1302249E-04	0.	.1302249E+03	.1953374E+02	.300E+05	0.
27	.15000	17.94000	-.1917661E-04	0.	-.1917661E+03	-.2876492E+02	.300E+05	0.
28	.15000	17.94000	.1918518E-04	0.	.1918518E+03	.2877777E+02	.300E+05	0.
29	.15000	17.97000	-.1333938E-04	0.	-.1333938E+03	-.2000906E+02	.300E+05	0.
30	.15000	17.97000	.1335298E-04	0.	.1335298E+03	.2002946E+02	.300E+05	0.
31	2.62500	3.30000	.7799723E-05	0.	.7799723E+02	.2047427E+03	.300E+05	0.
32	2.62500	3.30000	-.7797279E-05	0.	-.7797279E+02	-.2046786E+03	.300E+05	0.
33	2.62500	3.30000	-.5711478E-05	0.	-.5711478E+02	-.1499263E+03	.300E+05	0.
34	2.62500	3.30000	.5713587E-05	0.	.5713587E+02	.1499816E+03	.300E+05	0.
35	2.62500	12.70000	-.8683006E-06	0.	-.8683006E+01	-.2279289E+02	.300E+05	0.
36	2.62500	12.70000	.1094875E-05	0.	.1094875E+02	.2874047E+02	.300E+05	0.
37	2.62500	13.70000	.2005594E-04	0.	.2005594E+03	.5264684E+03	.300E+05	0.
38	2.62500	13.70000	-.1979825E-04	0.	-.1979825E+03	-.5197041E+03	.300E+05	0.
39	2.62500	14.90000	.2555673E-04	0.	.2555673E+03	.6708641E+03	.300E+05	0.
40	2.62500	14.90000	-.2522380E-04	0.	-.2522380E+03	-.6621247E+03	.300E+05	0.
41	1.87500	3.30000	.6541678E-04	0.	.6541678E+03	.1226602E+04	.300E+05	0.
42	1.87500	3.30000	-.6540832E-04	0.	-.6540832E+03	-.1226406E+04	.300E+05	0.
43	1.87500	3.30000	.7209157E-04	0.	.7209157E+03	.1351717E+04	.300E+05	0.
44	1.87500	3.30000	-.7206611E-04	0.	-.7206611E+03	-.1351240E+04	.300E+05	0.
45	1.87500	12.60000	.1066760E-03	0.	.1066760E+04	.2000175E+04	.300E+05	0.

Figure 3.4.11. (continued).

```
REPLICA WING / NON-LINEAR ANALYSIS / DAMAGE IN CHORD BAY 1 SPAN BAY 3
     CASE 1


SOLUTION TIME SUMMARY

INPUT AND TABLE SETUP...............          .834
ELEMENT MATRICES, EQUILIBRIUM
   CORRECTION AND STRESS RECOVERY...        70.170
MATRIX ASSEMBLIES...................         3.232
LOADS CALCULATION...................         1.885
EQUATION SOLUTIONS..................         4.333
DISPLACEMENT RECOVERY...............         3.126

TOTAL LOAD INCREMENTS...............      21
TOTAL ITERATION CYCLES..............      21


SUMMARY OF SEQUENTIAL I/O OPERATIONS

READ REQUESTS.......................         34949
WRITE REQUESTS......................         14634
WORDS TRANSFERRED (INPUT)...........        676897
WORDS TRANSFERRED (OUTPUT)..........        523074
```

Figure 3.4.1m. Solution Time and I/O Summaries.

```
 CSA     NOS/BE L481J       L481J-CMR1 01/11/80
17.25.16.UD5K34K  FROM
17.25.16.IP  00011536 WORDS - FILE INPUT  , DC 04
17.25.16.UD5K,T350,I3552,CM132000,STANY. D770643,
17.25.16.BRUNER,E3565,93351-94
17.25.23.      NO DECK
17.25.23.SET,R1=MFL.
17.25.23.ATTACH,P,MAGNAJCL,ID=BROCKMAN.
17.25.24.PF CYCLE NO. = 999
17.25.24.COPYCR,INPUT,TAPE5.
17.25.24.REQUEST,MPOST,*PF.
17.25.25.BEGIN,XMAGNA,P,MAIN,,R1+B.
17.25.26.SET,R2=0.
17.25.27.SET,R3=1.
17.25.27.IFE,NUM(MAIN)=0,SKIPM.
17.25.28.SET,R2=1.
17.25.29.ATTACH,UPDGEN,MAGNAUPDGEN,CY=2,ID=BROCKM
17.25.29.AN,SN=AFFDL.
17.25.29.UPDGEN.
17.25.40.     STOP
17.25.4..        .876 CP SECONDS EXECUTION TIME
17.25.40.RETURN,UPDGEN.
17.25.41.REWIND,MODS.
17.25.41.ATTACH,O.DPL,RABDRIVER,CY=1,ID=BROCKMAN,
17.25.41.SN=AFFDL.
17.25.41.UPDATE,P,I=MODS,L=6,R=C.
17.25.42. UPDATE COMPLETE.
17.25.43.RETURN,MODS.
17.25.43.FTN,I,OPT=2,B=MAIN,L,R=1,PL=999999.
17.25.47.        .218 CP SECONDS COMPILATION TIME
17.25.47.RETURN,OLDPL,COMPILE.
17.25.47.ENDIF,SKIPM.
17.25.48.IFE,NUM(B)=0,SKIPU.
17.25.48.ENDIF,SKIPU.
17.25.48.IFE,R2.EQ.0.AND.R3.EQ.0,GO.
17.25.48.ELSE,GO.
17.25.48.ATTACH,TEMP,MAGNALGO,CY=2,ID=BROCKMAN,SN
17.25.48.=AFFDL.
17.25.49.ENDIF,GO.
17.25.50.IFE,R2.GT.0.AND.R3.GT.0,COPYA.
17.25.50.ENDIF,COPYA.
17.25.50.IFE,R2.GT.0.AND.R3.EQ.0,COPYB.
17.25.51.REWIND,TEMP,MAIN,MAGNA.
17.25.51.COPY.M,TEMP,MAIN,MAGNA.
17.25.51. UPDATED -- REL   / MAIN
17.25.51. COPYL COMPLETE.
17.25.51.RETURN,TEMP,MAIN.
17.25.52.ENDIF,COPYB.
17.26.03.IFE,R2.EQ.0.AND.R3.GT.0,COPYC.
17.26.04.ENDIF,COPYC.
17.25.34.IFE,FILE(TAPE5,AS),GETDATA.
17.25.34.**************************
17.25.34.***** TAPE5 = LOCAL *****
17.25.34.**************************
17.26.04.ELSE,GETDATA.
17.26.05.ENDIF,GETDATA.
17.26.05.REWIND,TAPE5.
17.26.05.COPYSBF,TAPE5,OUTPUT.
17.25.07.REWIND,TAPE5.
17.25.07.ATTACH,UPDIN,MAGNALGO,CY=4,ID=BROCKMAN,S
17.26.07.N=AFFDL.
17.26.08.UPDATE,N,I=UPDIN,C=SEGLDU,D,8,R=C,L=0.
17.26.08.UPDATE CREATION RUN
```

Figure 3.4.1n. Day File.

```
17.25.11.CREATING NEW PROGRAM LIBRARY
17.25.12. UPDATE COMPLETE.
17.26.12.RETURN,NEWPL,UPDIN.
17.25.13.REWIND,MAGNA.
17.25.13.LIMIT,7777.
17.26.13.RFL,132400.
17.26.13.SUMMARY.
17.25.13.MS   64512  WORDS  (   68196 MAX USED)
17.25.13.CPA      1.234 SEC.        1.005 ADJ.
17.26.13.IO      28.863 SEC.        8.543 ADJ.
17.25.13.CM     209.318 KWS.         .985 ADJ.
17.25.13.CRUS                      10.535
17.25.13.COST              $          .69
17.26.13.PP      34.744 SEC.      DATE 01/07/80
17.25.14.LDSET(MAP=S/ERRORS)
17.25.14.SEGLOAD(I=SEGLOD)
17.26.14.MAGNA.
17.31.35.     NON-FATAL LOADER ERRORS - SEE MAP
17.38.37.    STOP
17.33.37.    55.571 CP SECONDS EXECUTION TIME
17.33.37.REVERT.
17.38.37.CATALOG,MPOST,AFFDLMPOST,RP=800.
17.35.38.INITIAL CATALOG
17.35.38.CT ID=  0771043 PFN=AFFDLMPOST
17.33.38.CT CY= 001  00124096 WORDS.
17.38.38.OP  00207872 WORDS - FILE OUTPUT , DC 40
17.33.38.MS  333312  WORDS  (  806460 MAX USED)
17.39.38.CPA     36.759 SEC.       78.851 ADJ.
17.35.38.IO     237.318 SEC.       88.003 ADJ.
17.33.38.CM   14051.305 KWS.       66.192 ADJ.
17.38.38.CRUS                     233.048
17.39.38.COST              $        15.36
17.39.38.PP     112.272 SEC.      DATE 01/07/80
17.39.38.EJ  END OF JOB, **  0770043.

************        UU5K04K  //// END OF LIST ////
************        UU5K04K  //// END OF LIST ////
```

Successful MAGNA Execution.

Successful Creation of WINGMPOST file.

Figure 3.4.1n. (continued).

```
M A T E R I A L L Y   A N D   G E O M E T R I C A L L Y
N O N L I N E A R   A N A L Y S I S
O F
T H R E E - D I M E N S I O N A L   S T R U C T U R E S

R E V I S E D     0 1 / 8 0
D O C U M E N T A T I O N :   U D R - T R - 7 9 - 4 5

U N I V E R S I T Y   O F   D A Y T O N
R E S E A R C H   I N S T I T U T E
3 0 0   C O L L E G E   P A R K
D A Y T O N   O H I O     4 5 4 6 9

REQUESTS FOR PROGRAM USE AND AVAILABILITY SHOULD BE REFERRED TO :

        DR. FRED K. BOGNER, GROUP LEADER
        ANALYTICAL MECHANICS GROUP
        RESEARCH INSTITUTE
        UNIVERSITY OF DAYTON
        DAYTON, OHIO  45469

USER QUESTIONS AND COMMENTS REGARDING THIS VERSION OF THE MAGNA
FINITE ELEMENT PROGRAM SHOULD BE DIRECTED TO :

        DR. ROBERT A. BROCKMAN
        RESEARCH ENGINEER
        ANALYTICAL MECHANICS GROUP
        RESEARCH INSTITUTE
        UNIVERSITY OF DAYTON
        DAYTON, OHIO  45469

        TELE. (513)-229-3618

LAST SYSTEM COMPATIBILITY UPDATE  -  NOS / BE , LEVEL 481 D
```

Figure 3.4.2. Sample listing of a linear analysis performed on a T-38 wing model.

```
MAGNA SYSTEM NOTES :

1.  TO AVOID DIFFICULTY IN ACCESSING THE MAGNA PROCEDURE FILE (MAGNAJCL),
    USE THE PARAMETER MR=1 ON THE CONTROL CARD ATTACHING THE FILE, E.G.,

    ATTACH,P,MAGNAJCL,ID=BROCKMAN,SN=AFFDL,MR=1.

2.  EIGENVALUE SOLUTION (NATURAL FREQUENCIES AND NORMAL MODES) IS NOW
    AVAILABLE IN MAGNA.  DOCUMENTATION WILL BE INCLUDED IN THE NEXT RELEASE
    OF THE USERS MANUAL.

3.  AN AVERAGED STIFFNESS FORMULATION IS NOW AVAILABLE FOR THE VARIABLE-
    NODE SOLID (ELEMENT TYPE 1), WHICH CAN RESULT IN SIGNIFICANT TIME SAVINGS
    FOR NONLINEAR ANALYSIS.  THE OPTION IS TURNED ON ELEMENT BY ELEMENT, BY
    SPECIFYING ISUP=-1 ON THE ELEMENT DEFINITION CARD.  IT IS SUGGESTED THAT
    THIS OPTION BE USED ONLY WITH ITERATION TO MAINTAIN ACCURACY.

4.  THREE NEW ELEMENT TYPES ARE AVAILABLE IN MAGNA WHICH ARE NOT DESCRIBED
    IN THE USERS MANUAL.  ALL THREE ELEMENTS ARE THREE-DIMENSIONAL, AND
    SHOULD BE USED IN PREFERENCE TO ELEMENT TYPE 1 WHEN POSSIBLE BECAUSE
    OF THEIR INCREASED EFFICIENCY.  THE NEW ELEMENTS ARE -

    EL. TYPE 6 - 3-D SOLID 20-NODE BRICK
    EL. TYPE 7 - 3-D SOLID ELEMENT WITH VARIABLE NUMBER OF NODES ( 8 TO 20 )
    EL. TYPE 8 - 3-D SOLID / THICK SHELL WITH 16 NODES

    NODAL CONFIGURATIONS FOR EACH OF THESE ELEMENTS FOLLOW THE SAME CONVENTION
    AS ELEMENT TYPE 1.  INPUT DATA FOR ELEMENTS 6, 7 AND 8 IS EXACTLY THE SAME
    AS FOR ELEMENT TYPE 1 (E.G., THE 16-NODE ELEMENT CONSISTS OF ALL VERTEX
    AND MIDSIDE NODES ON THE UPPER AND LOWER ELEMENT SURFACES, ETC.).  ONLY
    THE ELEMENT TYPE HEADER  MUST BE CHANGED (SEE SECTION 8.5.1 OF MANUAL).
    THE AVERAGED STIFFNESS OPTION (ITEM 3 ABOVE ) IS INCLUDED IN ALL THREE
    OF THE NEW ELEMENT TYPES.

5.  MOST OF THE THREE-DIMENSIONAL ELEMENTS IN MAGNA NOW INCLUDE THE OPTION
    FOR ANALYZING ORTHOTROPIC MATERIALS.  ELEMENT TYPES 1, 6, 7 AND 8
    PRESENTLY HAVE THIS FEATURE.  THEORETICAL DEVELOPMENT AND EXAMPLES OF
    ORTHOTROPIC MATERIAL INPUT DATA ARE DOCUMENTED IN UDR-TM-86-15.  COPIES
    OF THIS MEMO ARE AVAILABLE UPON REQUEST.
```

Figure 3.4.2. (continued).

```
WORKING ARRAY REDEFINITION                MAGNA / UPDGEN              05/16/80     19.18.20.

    LABELLED COMMON AREA           LENGTH          DEFAULT          MINIMUM

          /BLANK/       NWORK    = 12000           24000            12000
          /IDENT/       NID      =   168            2500              100
          /BLOX /       NNS      =   150             150              150
          /BLEQ /       NNS      =   150             150              150
          /INDXK/       NINDXK   =   170             170              170

                                  DECIMAL      OCTAL
CENTRAL MEMORY ( DEFAULT ) . . .   56320      156000
ARRAY EXTENSIONS . . . . . . . .  -14332      744003
CENTRAL MEMORY (ESTIMATE)) . . .   41988      122004
```

Figure 3.4.2. (continued).

```
      PROGRAM MAIN                                                          IOOCT79     1
     +(              TAPE5 =100/90 , OUTPUT=60L    , TAPE6 =OUTPUT,         IOOCT79     2
     +               MPOST =160    , TAPE99=MPOST  , TAPE24=512   ,         IOOCT79     3
     +               TAPE10=1010   , TAPE21=60F    ,                        IOOCT79     4
     +               TAPE11=512    , TAPE12=1910   , TAPE13=512   ,         IOOCT79     5
     +               TAPE14=512    , TAPE15=512    , TAPE16=512   ,         IOOCT79     6
     +               TAPE17=512    , TAPE18=512    , TAPE20=512   ,         IOOCT79     7
     +               TAPE22=512    , TAPE23=512    , TAPE50=512   )         IOOCT79     8
C                                                                           MAIN       11
      COMMON /BLANK/        A    (    12000 )                               WKAREA      1
      COMMON /IDENT/       ID    (      168 )                               WKAREA      2
      COMMON /BLOX /    NSHFT    (      150 )                               WKAREA      3
      COMMON /BLEQ /   NEQLIM    (      150 )                               WKAREA      4
      COMMON /INDXK/     INDK    (      170 )                               WKAREA      5
      COMMON /POSTPR/ IFP,NPFILE,NETYPU                                     MAIN       17
      COMMON /C32   / I32(11)                                               MAIN       18
      COMMON /C33/    XG(10),WG(10)                                         MAIN       19
      COMMON /C34/    I34(7)                                                MAIN       20
      COMMON /HED1/   TITLE(8,3)                                            MAIN       21
      COMMON /DP/     IDF                                                   MAIN       22
      COMMON /INDXM/ IND21(56)                                              MAIN       23
      COMMON /ELTYP1/NELTYP,NDFTYP(20),NEL(20)                              MAIN       24
      COMMON /ELTYP2/NNOD(20),NPAR(10,20),NFORD(20)                         MAIN       25
      COMMON /TIMSTP/ ICTIME(4),CDT(4),NCTIME                               MAIN       26
      COMMON/MPART/N,NLC,NBLK,NLR,NWORK,MAXSIZ,NINDXK,NID,NNS,NOLD,NBOLD    MAIN       27
      COMMON /DOF/ NFVAR,NDPVPN,NDPN,MAXKOD,NBC1,NBC2,NI,NLCC,MLCT          ALLTOGFN    1
      COMMON /VCARAY/LVC(100)                                               MAIN       29
      COMMON /CTRL/  NODES,IOPT(20),IPRF,NSTEP,ISTEP                        MAIN       30
      COMMON /DYNINT/ALFA,BETA,GAMA,DLTA,DT,TZERO,T                         MAIN       31
      COMMON / EQIT1/ LODCOR,INTRVL,MAXIT,EQTOL,DISTOL                      EQMAIN1     1
      COMMON / EQIT2/ PNORM,PNORMP,DNORM,DNORMP                             EQMAIN1     2
      COMMON / EQIT3/ IPRINT,IPOST,NOMAT,NOMATP,LCIT,NUMIT,ITERS,ISTOP      EQMAIN1     3
      COMMON /PCOM1/ PC1(190)                                               MAXCOM1     1
      COMMON /PCOM2/ PC2(52)                                                MAXCOM1     2
      COMMON /PCOM3/ PC3(180)                                               ORTHCOM     1
      COMMON /GRAPH/ ABX(20),ORD(20),NCURV,NPTS(50)                         MAIN       35
      COMMON /FILNAM/ NIN,NOUT,IFILE(20)                                    NEWFN2      1
      COMMON /ANISO / PRP(1)                                                IOOCT79     9
      COMMON/LODLOC/LLOC(25)                                                MAIN       38
      COMMON /IMPLD/ PLD(16)                                                MAIN       39
      COMMON /EIGN1/ DATA1(10)                                              EIGEN       1
      COMMON /EIGN2/ DATA2(100)                                             EIGEN       2
      COMMON /EIGN3/ DATA3(70)                                              MAXCOM1     3
      COMMON /USERC/ USPACE(20)                                             MAIN       40
      COMMON /SIO   / IOREQS(4)                                             MAIN       41
C                                                                           MAIN       42
C         NNS      =  150                                                   WKAREA      6
          NWORK    =12000                                                   WKAREA      7
          NID      =  168                                                   WKAREA      8
          NNS      =  150                                                   WKAREA      9
          NINDXK   =  170                                                   WKAREA     10
      NINDXM=56                                                             MAIN       48
      IDP    =     1                                                        MAIN       49
      CALL SETFN                                                            ALLTOGFN    3
      CALL INITIN (NIN,NOUT)                                                MAIN       54
      IVSET  = IOPT(1)                                                      MAIN       55
      GO TO (10,20,510,500,500),IVSET                                       MAIN       56
```

Figure 3.4.2. (continued)

```
        10  CALL SETUP1                                                        MAIN      57
            GO TO 210                                                          MAIN      58
         20 CONTINUE                                                           NOSET2C    1
            GO TO 510                                                          NOSET2C    2
      C                                                                        MAIN      61
      C                                                                        MAIN      62
      C                                                                        MAIN      63
        210 CONTINUE                                                           MAIN      64
            CALL IOINIT (NINOKM,NINOXK)                                        MAIN      65
      C                                                                        MAIN      66
      C     1. LINEAR STATIC ANALYSIS                                          MAIN      67
      C                                                                        MAIN      68
            IF ( IOPT(2).EQ.1   .AND.                                          MAIN      69
     +           IOPT(3).EQ.1   .AND.                                          MAIN      70
     +           IOPT(4).EQ.1          )    CALL CNTL01                        MAIN      71
      C                                                                        MAIN      72
      C     2. LINEAR DYNAMIC ANALYSIS                                         MAIN      73
      C                                                                        MAIN      74
            IF ( IOPT(2).EQ.2   .AND.                                          MAIN      75
     +           IOPT(3).EQ.1   .AND.                                          MAIN      76
     +           IOPT(4).EQ.1          )    CALL CNTL02                        MAIN      77
      C                                                                        MAIN      78
      C     3. FREE VIBRATION ANALYSIS                                         MAIN      79
      C                                                                        MAIN      80
            IF ( IOPT(2).EQ.3          )   CALL CNTL03                         EIGLN      3
      C                                                                        MAIN      82
      C     4. NONLINEAR STATIC ANALYSIS                                       MAIN      83
      C                                                                        MAIN      84
            IF ( IOPT(2).EQ.1   .AND.                                          MAIN      85
     +        ( IOPT(3).GT.1   .OR.                                            MAIN      86
     +           IOPT(4).GT.1         ))    CALL CNTL04                        MAIN      87
      C                                                                        MAIN      88
      C     5. NONLINEAR DYNAMIC ANALYSIS                                      MAIN      89
      C          (IMPLICIT INTEGRATION)                                        MAIN      90
      C                                                                        MAIN      91
            IF ( IOPT(2).EQ.2   .AND.                                          MAIN      92
     +           IOPT(5).EQ.1   .AND.                                          MAIN      93
     +        ( IOPT(3).GT.1   .OR.                                            MAIN      94
     +           IOPT(4).GT.1         ))    CALL CNTL05                        MAIN      95
      C                                                                        MAIN     104
        510 STOP                                                               MAIN     105
            END                                                                MAIN     106
```

```
   SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
24276  MAIN

VARIABLES       SN  TYPE               RELOCATION
    6  A            REAL        ARRAY    BLANK          0  ABX        REAL       ARRAY   GRAPH
    6  ALFA         REAL                 DYNINT         1  BETA       REAL               DYNINT
    4  COT          REAL        ARRAY    TIMSTP         0  DATA1      REAL       ARRAY   EIGN1
    6  DATA2        REAL        ARRAY    EIGN2          0  DATA3      REAL       ARRAY   EIGN3
```

Figure 3.4.2. (continued

```
        PROGRAM MAIN       74/74    OPT=2                        FTN 4.8+498          05/16/80  19.18.24        PAGE     3

VARIABLES      SN  TYPE            RELOCATION
    4  DISTOL    REAL                  EQIT1           3  DLTA       REAL                  DYNINT
    2  DNORM     REAL                  EQIT2           3  DNORMP     REAL                  EQIT2
    4  DT        REAL                  DYNINT          3  EQTOL      REAL                  EQIT1
    2  GAMA      REAL                  DYNINT          0  ICTIME     INTEGER    ARRAY      TIMSTP
    0  IO        INTEGER    ARRAY      IDENT           0  IDP        INTEGER               DP
    2  IFILE     INTEGER    ARRAY      FILNAM          0  INDK       INTEGER    ARRAY      INDXK
    0  IND21     INTEGER    ARRAY      INDXM           1  INTRVL     INTEGER               EQIT1
    1  IOPT      INTEGER    ARRAY      CTRL            0  IOREOS     INTEGER    ARRAY      SIO
    1  IPOST     INTEGER               EQIT3           0  IPP        INTEGER               POSTPR
   25  IPRF      INTEGER               CTRL            0  IPRINT     INTEGER               EQIT3
   27  ISTEP     INTEGER               CTRL            7  ISTOP      INTEGER               EQIT3
    6  ITERS     INTEGER               EQIT3       24377  IVSET      INTEGER
    0  I32       INTEGER    ARRAY      C32             0  I34        INTEGER    ARRAY      C34
    4  LCIT      INTEGER               EQIT3           0  LLOC       INTEGER    ARRAY      LODLOC
    0  LODCOR    INTEGER               EQIT1           0  LVC        INTEGER    ARRAY      VCARAY
    2  MAXIT     INTEGER               EQIT1           3  MAXKOD     INTEGER               DOF
    5  MAXSIZ    INTEGER               MPART          10  MLCT       INTEGER               DOF
    0  N         INTEGER               MPART           4  NBC1       INTEGER               DOF
    5  NBC2      INTEGER               DOF             2  NBLK       INTEGER               MPART
   12  NBOLD     INTEGER               MPART          10  NCTIME     INTEGER               TIMSTP
   50  NCURV     INTEGER               GRAPH           1  NDFTYP     INTEGER    ARRAY      ELTYP1
    2  NDFN      INTEGER               DOF             1  NDPVPN     INTEGER               DOF
   25  NEL       INTEGER    ARRAY      ELTYP1          0  NELTYP     INTEGER               ELTYP1
    0  NEQLIM    INTEGER    ARRAY      BLED            2  NETYPU     INTEGER               POSTPR
  334  NFORD     INTEGER    ARRAY      ELTYP2          0  NFVAR      INTEGER               DOF
    6  NI        INTEGER               DOF             7  NID        INTEGER               MPART
    0  NIN       INTEGER               FILNAM          6  NINDXK     INTEGER               MPART
  376  NINDXM    INTEGER                               1  NLC        INTEGER               MPART
    7  NLCC      INTEGER               DOF             3  NLR        INTEGER               MPART
    0  NNOD      INTEGER    ARRAY      ELTYP2         10  NNS        INTEGER               MPART
    0  NODES     INTEGER               CTRL           11  NOLD       INTEGER               MPART
    2  NOMAT     INTEGER               EQIT3           3  NOMATP     INTEGER               EQIT3
    1  NOUT      INTEGER               FILNAM         24  NPAR       INTEGER    ARRAY      ELTYP2
    1  NPFILE    INTEGER               POSTPR         51  NPTS       INTEGER    ARRAY      GRAPH
    0  NSHFT     INTEGER    ARRAY      BLOX           26  NSTEP      INTEGER               CTRL
    5  NUMIT     INTEGER               EQIT3           4  NWORK      INTEGER               MPART
   24  ORD       REAL       ARRAY      GRAPH           0  PC1        REAL       ARRAY      PCOM1
    0  PC2       REAL       ARRAY      PCOM2           0  PC3        REAL       ARRAY      PCOM3
    0  PLD       REAL       ARRAY      IMPLD           0  PNORM      REAL                  EQIT2
    1  PNORMP    REAL                  EQIT2           0  PRP        REAL       ARRAY      ANISO
    6  T         REAL                  DYNINT          0  TITLE      REAL       ARRAY      HED1
    5  TZERO     REAL                  DYNINT          0  USPACE     REAL       ARRAY      USERC
   12  WG        REAL       ARRAY      C33             0  XG         REAL       ARRAY      C33

FILE NAMES        MODE
  1435  MPOST                   231  OUTPUT            3025  TAPE10             6255  TAPE11
  7331  TAPE12                11355  TAPE13           12431  TAPE14            13565  TAPE15
 14561  TAPE16                15635  TAPE17           16711  TAPE18            17765  TAPE20
  5051  TAPE21                21041  TAPE22           22115  TAPE23             1751  TAPE24
     0  TAPE5                 23171  TAPE50             231  TAPE5              1435  TAPE99

EXTERNALS         TYPE    ARGS
       CNTL01              0                 CNTL02              0
       CNTL03              0                 CNTL04              0
       CNTL05              0                 INITIN              2
       IOINIT              2                 SETFN               0
       SETUP1              0
```

Figure 3.4.2 (continued).

```
        PROGRAM MAIN       74/74    OPT=2                        FTN 4.8+498        05/16/80  19.18.24        PAGE     4

TATEMENT LABELS
4322  13                         24324  20                         24325  200
4366  50(

OMMON BLOCKS    LENGTH
          BLANK     12100
          IDENT       568
          BLOX        150
          BLFQ        150
          INDXK       170
          POSTPR        3
          C32          11
          C33          20
          C34           7
          HED1         24
          DP            1
          INDXM        56
          ELTYP1       41
          ELTYP2      240
          TIMSTP        9
          MPART        11
          DOF           9
          VCARAY      100
          CTRL         24
          DYNINT        7
          EQIT1         5
          EQIT2         4
          EQIT3         8
          PCOM1       190
          PCOM2        52
          PCOM3       180
          GRAPH        91
          FILNAM       22
          ANISO         1
          LODLOC       25
          IMPLD        16
          EIGN1        16
          EIGN2       100
          EIGN3        70
          USERC        21
          SIO           4

TATISTICS
  PROGRAM LENGTH              1617B      911
  BUFFER LENGTH              22561B     9585
  CM LABELED COMMON LENGTH   33257B    13999
         60000B CM USED
```

Figure 3.4.2. (continued).

```
T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
  CASE 4 - FIRST TEST

 1   1   1   1   0   1   1   0   0   0   1
 1   1
  1.0000    6.0000
   .2500     .5000
   .0000     .0000
COORDINATES     56
    1         0.0000    0.0000   -2.1600
    2         0.0000    0.0000    2.1600
    3         6.3900    0.0000   -2.2657
    4         6.3900    0.0000    2.2657
    5        12.8500    0.0000   -2.3726
    6        12.8500    0.0000    2.3726
    7        19.3800    0.0000   -2.4806
    8        19.3800    0.0000    2.4806
    9        25.9900    0.0000   -2.5980
   10        25.9900    0.0000    2.5980
   11        31.5500    0.0000   -2.5750
   12        31.5500    0.0000    2.5750
   13        58.4800    0.0000   -2.1900
   14        58.4800    0.0000    2.1900
   15         0.0000   29.9200   -2.1600
   16         0.0000   29.9200    2.1600
   17         6.4386   28.9677   -2.2664
   18         6.4386   28.9677    2.2664
   19        12.9183   28.0093   -2.3734
   20        12.9183   28.0093    2.3734
   21        19.4446   27.0440   -2.4812
   22        19.4446   27.0440    2.4812
   23        26.0300   26.0700   -2.5900
   24        26.0300   26.0700    2.5900
   25        31.5500   25.2600   -2.5750
   26        31.5500   25.2600    2.5750
   27        58.4800   25.2300   -2.1900
   28        58.4800   25.2300    2.1900
   29        18.1400   64.8000   -1.3750
   30        18.1400   64.8000    1.3750
   31        23.4229   64.8000   -1.4994
   32        23.4229   64.8000    1.4994
   33        28.7156   64.8000   -1.6241
   34        28.7156   64.8000    1.6241
   35        34.0273   64.8000   -1.7492
   36        34.0273   64.8000    1.7492
   37        39.3700   64.8000   -1.8750
   38        39.3700   64.8000    1.8750
   39        43.8300   64.8000   -1.8750
   40        43.8300   64.8000    1.8750
   41        63.8600   64.8000   -1.4600
   42        63.8600   64.8000    1.4600
   43        36.8200  101.0000   -1.1700
   44        36.8200  101.0000    1.1700
   45        40.6000  101.0000   -1.2626
   46        40.6000  101.0000    1.2626
   47        44.3700  101.0000   -1.3550
   48        44.3700  101.0000    1.3550
   49        48.1400  101.0000   -1.4474
   50        48.1400  101.0000    1.4474
   51        51.9200  101.0000   -1.5400
   52        51.9200  101.0000    1.5400
   53        55.3600  101.0000   -1.5400
```

Figure 3.4.2. (continued).

```
  54        55.0600  101.0000     1.5400
  55        69.2700  101.0000    -1.3100
  56        69.2700  101.0000     1.3100

   3     2    77
.1000E+08 .3000E+00 .00025900  10000.00
.3000E+08 .3320E+08 .00072500  30000.00
   1     1     1                  1     3    17    15      .3300
   2     1     1                  2     4    18    16      .2800
   3     1     1                  3     5    19    17      .3300
   4     1     1                  4     6    20    18      .2800
   5     1     1                  5     7    21    19      .3300
   6     1     1                  6     8    22    20      .2800
   7     1     1                  7     9    23    21      .3300
   8     1     1                  8    10    24    22      .2800
   9     1     1                  9    11    25    23      .3300
  10     1     1                 10    12    26    24      .2800
  11     1     1                 15    17    31    29      .2600
  12     1     1                 16    18    32    30      .2300
  13     1     1                 17    19    33    31      .2600
  14     1     1                 18    20    34    32      .2300
  15     1     1                 19    21    35    33      .2600
  16     1     1                 20    22    36    34      .2300
  17     1     1                 21    23    37    35      .2600
  18     1     1                 22    24    38    36      .2300
  19     1     1                 23    25    39    37      .2600
  20     1     1                 24    26    40    38      .2300
  21     1     1                 25    27    41    39      .2600
  22     1     1                 26    28    42    40      .2300
  23     1     1                 29    31    45    43      .1800
  24     1     1                 30    32    46    44      .1600
  25     1     1                 31    33    47    45      .1800
  26     1     1                 32    34    48    46      .1600
  27     1     1                 33    35    49    47      .1800
  28     1     1                 34    36    50    48      .1600
  29     1     1                 35    37    51    49      .1800
  30     1     1                 36    38    52    50      .1600
  31     1     1                 37    39    53    51      .1800
  32     1     1                 38    40    54    52      .1600
  33     1     1                 39    41    55    53      .1800
  34     1     1                 40    42    56    54      .1600
  35     3     1                  1     3     4     2      .0800
  36     3     1                  3     5     6     4      .0800
  37     3     1                  5     7     8     6      .0800
  38     3     1                  7     9    10     8      .0800
  39     3     1                  9    11    12    10      .0800
  40     3     1                 15    17    18    16      .0800
  41     3     1                 17    19    20    18      .0800
  42     3     1                 19    21    22    20      .0800
  43     3     1                 21    23    24    22      .0800
  44     3     1                 23    25    26    24      .0800
  45     3     1                 25    27    28    26      .0800
  46     3     2                 29    31    32    30      .1000
  47     3     2                 31    33    34    32      .1000
  48     3     2                 33    35    36    34      .1000
  49     3     2                 35    37    38    36      .1000
  50     3     2                 37    39    40    38      .1000
  51     3     2                 39    41    42    40      .1000
  52     3     1                 43    45    46    44      .1000
  53     3     1                 45    47    48    46      .1000
  54     3     1                 47    49    50    48      .1000
  55     3     1                 49    51    52    50      .1000
  56     3     1                 51    53    54    52      .1000
  57     3     1                 53    55    56    54      .1000
  58     3     1                  1    15    16     2      .1600
  59     3     1                 15    29    30    16      .1600
```

Figure 3.4.2. (continued).

60	3	1	29	43	44	30	.1600
61	3	1	3	17	18	4	.0800
62	3	1	17	31	32	18	.0800
63	3	1	31	45	46	32	.0800
64	3	1	5	19	20	6	.0800
65	3	1	19	33	34	20	.0800
66	3	1	33	47	48	34	.0800
67	3	1	7	21	22	8	.0800
68	3	1	21	35	36	22	.0800
69	3	1	35	49	50	36	.0800
70	3	1	9	23	24	10	.0800
71	3	1	23	37	38	24	.0800
72	3	1	37	51	52	38	.0800
73	3	1	11	25	26	12	.0800
74	3	1	25	39	40	26	.0800
75	3	1	39	53	54	40	.0800
76	3	1	27	41	42	28	.0800
77	3	1	41	55	56	42	.0800

```
    4     2   113
.1600E+08 .00025900  10000.00
.3000E+08 .00072500  30000.00
```

1	1	1	3	.1000
2	1	2	4	.1100
3	1	3	5	.1000
4	1	4	6	.1000
5	1	5	7	.1000
6	1	6	8	.1000
7	1	7	9	.1000
8	1	8	10	.1000
9	1	9	11	.1000
10	1	14	12	.1000
11	1	15	17	.1500
12	1	16	18	.1500
13	1	17	19	.1500
14	1	18	20	.1500
15	1	19	21	.1500
16	1	20	22	.1500
17	1	21	23	.1500
18	1	22	24	.1500
19	1	23	25	.1500
20	1	24	26	.1500
21	1	25	27	.1500
22	1	26	28	.1500
23	1	29	31	.1000
24	1	30	32	.1000
25	1	31	33	.1000
26	1	32	34	.1000
27	1	33	35	.1600
28	1	34	36	.1500
29	1	35	37	.2800
30	1	36	38	.2900
31	1	37	39	.2800
32	1	38	40	.2800
33	1	39	41	.1400
34	1	40	42	.1400
35	1	43	45	.1700
36	1	44	46	.1000
37	1	45	47	.1000
38	1	46	48	.1000
39	1	47	49	.1000
40	1	48	50	.1250
41	1	49	51	.1150
42	1	50	52	.1450
43	1	51	53	.1250
44	1	52	54	.1750

Figure 3.4.2. (continued).

45	1	53	55	.1000
46	1	54	56	.1250
47	1	1	15	.1000
48	1	2	16	.1500
49	1	15	29	.1000
50	1	16	30	.1500
51	1	29	43	.1000
52	1	30	44	.1500
53	1	3	17	.1000
54	1	4	18	.1500
55	1	17	31	.1000
56	1	18	32	.1500
57	1	31	45	.1000
58	1	32	46	.1500
59	1	5	19	.1000
60	1	6	20	.1500
61	1	19	33	.1000
62	1	20	34	.1500
63	1	33	47	.1000
64	1	34	48	.1500
65	1	7	21	.1000
66	1	8	22	.1500
67	1	21	35	.1000
68	1	22	36	.1500
69	1	35	49	.1000
70	1	36	50	.1500
71	1	9	23	.1000
72	1	10	24	.1500
73	1	23	37	.1000
74	1	24	38	.1500
75	1	37	51	.1000
76	1	38	52	.1500
77	1	11	25	.1000
78	1	12	26	.1500
79	1	25	39	.1000
80	1	26	40	.1500
81	1	39	53	.1000
82	1	40	54	.1500
83	1	27	41	.1000
84	1	28	42	.1500
85	1	41	55	.1000
86	1	42	56	.1500
87	1	1	2	.0800
88	1	3	4	.0800
89	1	5	6	.0800
90	1	7	8	.0800
91	1	9	10	.0800
92	1	11	12	.0800
93	1	15	16	.0800
94	1	17	18	.0800
95	1	19	20	.0800
96	1	21	22	.0800
97	1	23	24	.0800
98	1	25	26	.0800
99	1	27	28	.0800
100	1	29	30	.0800
101	1	31	32	.0800
102	1	33	34	.0800
103	1	35	36	.0800
104	1	37	38	.0800
105	1	39	40	.0800
106	1	41	42	.0800
107	1	43	44	.0800
108	1	45	46	.0800
109	1	47	48	.0800
110	1	49	50	.0800

Figure 3.4.2. (continued).

111	1	51	52	.0300
112	1	53	54	.0300
113	1	55	56	.0300

1	1		
1	16	1	
1	2	3	
1	2	3	
25	26	27	28
1			
1	43	1	31.47
1	43	2	2058.63
1	43	3	142.13
1	44	1	-31.47
1	44	2	-2058.63
1	44	3	142.13
1	45	1	73.21
1	45	2	4788.61
1	45	3	-143.00
1	46	1	-73.21
1	46	2	-4788.61
1	46	3	-143.00
1	47	1	84.20
1	47	2	5507.64
1	47	3	33.51
1	48	1	-84.20
1	48	2	-5507.64
1	48	3	33.51
1	49	1	95.20
1	49	2	6292.54
1	49	3	252.56
1	50	1	-95.20
1	50	2	-6292.54
1	50	3	252.56
1	51	1	93.82
1	51	2	6523.25
1	51	3	585.65
1	52	1	-93.82
1	52	2	-6523.25
1	52	3	585.65
1	53	1	251.27
1	53	2	16377.30
1	53	3	906.03
1	54	1	-251.27
1	54	2	-16377.30
1	54	3	906.03
1	55	1	143.32
1	55	2	9701.80
1	55	3	2415.58
1	56	1	-143.32
1	56	2	-9701.80
1	56	3	2415.58

Figure 3.4.2. (continued).

```
     T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
       CASE 4 = FIRST TEST

VARIABLE SET CODE                     1
  1 = DISPLACEMENTS U,V,W
  2 = U,V,W + DERIVATIVES
SOLUTION OPTION                       1
  1 = STATIC ANALYSIS
  2 = DYNAMIC ANALYSIS
  3 = NATURAL FREQUENCY
MATERIAL NONLINEARITY FLAG            1
  1 = ELASTIC
  2 = ELASTIC-PLASTIC
GEOMETRIC NONLINEARITY FLAG           1
  1 = SMALL DISPLACEMENT
  2 = LARGE DISPLACEMENT
DYNAMIC SOLUTION OPTION               1
  1 = NEWMARK INTEGRATION
  2 = CENTRAL DIFFERENCE
STIFFNESS REFORMATION INTERVAL        1
MATRIX PROFILE MAP OPTION FLAG        1
WRITE-IN-PLACE FLAG                   0

IMPACT LOADS GENERATOR FLAG           0
  STORAGE ALLOC (1=DEFAULT)           0
USER-DEFINED INCREMENTAL LOADS        1
  0 = NORMAL LOADS INPUT
  1 = USER LOADS ROUTINE

POSTPROCESSOR FILE WRITE FLAG         1
  0 = NO OUTPUT
  1 = DATA ON FILE MPOST

NUMBER OF TIME STEP CHANGES           0

NUMBER OF SOLUTION TIME STEPS         1
PRINT FREQUENCY                       1

INITIAL TIME INCREMENT   .10000E+01
INITIAL TIME                0.

TIME INTEGRATION COEFFICIENTS
ALPHA                    .25000E+00
DELTA                    .50000E+00

RAYLEIGH DAMPING COEFFICIENTS
BETA                        0.
GAMMA                       0.
```

Figure 3.4.2. (continued).

T38 WING / LINEAR ANALYSIS / MODEL DEVELOPMENT
CASE 4 - FIRST TEST

NODAL COORDINATES

NODE	X	Y	Z
1	0.00000	0.00000	-2.16000
2	0.00000	0.00000	2.16000
3	6.39000	0.00000	-2.26570
4	6.39000	0.00000	2.26570
5	12.85000	0.00000	-2.37260
6	12.85000	0.00000	2.37260
7	19.38000	0.00000	-2.48060
8	19.38000	0.00000	2.48060
9	25.99000	0.00000	-2.59000
10	25.99000	0.00000	2.59000
11	31.55000	0.00000	-2.57500
12	31.55000	0.00000	2.57500
13	58.48000	0.00000	-2.19000
14	58.48000	0.00000	2.19000
15	0.00000	29.92000	-2.16000
16	0.00000	29.92000	2.16000
17	6.43860	28.96770	-2.26640
18	6.43860	28.96770	2.26640
19	12.91830	28.00930	-2.37340
20	12.91830	28.00930	2.37340
21	19.44460	27.04400	-2.48120
22	19.44460	27.04400	2.48120
23	26.03000	26.07000	-2.59000
24	26.03000	26.07000	2.59000
25	31.55000	25.26000	-2.57500
26	31.55000	25.26000	2.57500
27	58.48000	25.23000	-2.19000
28	58.48000	25.23000	2.19000
29	18.14000	64.80000	-1.37500
30	18.14000	64.80000	1.37500
31	23.42290	64.80000	-1.49940
32	23.42290	64.80000	1.49940
33	28.71560	64.80000	-1.62410
34	28.71560	64.80000	1.62410
35	34.02730	64.80000	-1.74920
36	34.02730	64.80000	1.74920
37	39.37000	64.80000	-1.87500
38	39.37000	64.80000	1.87500
39	43.83000	64.80000	-1.87500
40	43.83000	64.80000	1.87500
41	63.86000	64.80000	-1.46000
42	63.86000	64.80000	1.46000
43	36.82000	101.00000	-1.17000
44	36.82000	101.00000	1.17000
45	40.60000	101.00000	-1.26260
46	40.60000	101.00000	1.26260
47	44.37000	101.00000	-1.35500
48	44.37000	101.00000	1.35500
49	48.14000	101.00000	-1.44740
50	48.14000	101.00000	1.44740

Figure 3.4.2. (continued).

51	51.92000	101.00000	-1.54000
52	51.92000	101.00000	1.54000
53	55.06000	101.00000	-1.54000
54	55.06000	101.00000	1.54000
55	69.27000	101.00000	-1.31000
56	69.27000	101.00000	1.31000

Figure 3.4.2. (continued).

INPUT FOR ELEMENT TYPE 3   TWO-DIMENSIONAL PLANE STRESS, PLANE STRAIN AND SHEAR WEB ELEMENTS

MATERIAL PROPERTIES

MATL	MODULUS	POISSON RATIO	DENSITY	YIELD	MX.INC.STRAIN	GAMMA	HARDENING	S-E CURVE
1	.10000E+08	.360000	.000259					
2	.30000E+08	.330000	.000725					

ELEMENT CONNECTIVITY   TWO-DIMENSIONAL ELEMENTS

ITYPE =1 : PLANE STRESS ELEMENTS
ITYPE =2 : PLANE STRAIN ELEMENTS
ITYPE =3 : SHEAR PANEL ELEMENTS

ELEM	ITYPE	MATL	INT	KGEN	NODE1	NODE2	NODE3	NODE4	THICKNESS	BEND.FLAG
1	1	1	2	0	1	3	17	15	.3300	0
2	1	1	2	0	2	4	18	16	.2800	0
3	1	1	2	0	3	5	19	17	.3300	0
4	1	1	2	0	4	6	20	18	.2800	0
5	1	1	2	0	5	7	21	19	.3300	0
6	1	1	2	0	6	8	22	20	.2800	0
7	1	1	2	0	7	9	23	21	.3300	0
8	1	1	2	0	8	10	24	22	.2800	0
9	1	1	2	0	9	11	25	23	.3300	0
10	1	1	2	0	10	12	26	24	.2800	0
11	1	1	2	0	15	17	31	29	.2600	0
12	1	1	2	0	16	18	32	30	.2300	0
13	1	1	2	0	17	19	33	31	.2600	0
14	1	1	2	0	18	20	34	32	.2300	0
15	1	1	2	0	19	21	35	33	.2600	0
16	1	1	2	0	20	22	36	34	.2300	0
17	1	1	2	0	21	23	37	35	.2600	0
18	1	1	2	0	22	24	38	36	.2300	0
19	1	1	2	0	23	25	39	37	.2600	0
20	1	1	2	0	24	26	40	38	.2300	0
21	1	1	2	0	25	27	41	39	.2600	0
22	1	1	2	0	26	28	42	40	.2300	0
23	1	1	2	0	29	31	45	43	.1800	0
24	1	1	2	0	30	32	46	44	.1600	0
25	1	1	2	0	31	33	47	45	.1800	0
26	1	1	2	0	32	34	48	46	.1600	0
27	1	1	2	0	33	35	49	47	.1800	0
28	1	1	2	0	34	36	50	48	.1600	0
29	1	1	2	0	35	37	51	49	.1800	0
30	1	1	2	0	36	38	52	50	.1600	0
31	1	1	2	0	37	39	53	51	.1800	0
32	1	1	2	0	38	40	54	52	.1600	0
33	1	1	2	0	39	41	55	53	.1800	0
34	1	1	2	0	40	42	56	54	.1600	0
35	3	1	2	0	1	3	4	2	.0800	0
36	3	1	2	0	3	5	6	4	.0800	0
37	3	1	2	0	5	7	8	6	.0800	0
38	3	1	2	0	7	9	10	8	.0800	0
39	3	1	2	0	9	11	12	10	.0800	0
40	3	1	2	0	15	17	18	16	.0800	0
41	3	1	2	0	17	19	20	18	.0800	0
42	3	1	2	0	19	21	22	20	.0800	0
43	3	1	2	0	21	23	24	22	.0800	0

Figure 3.4.2. (continued).

44	3	1	2	0	23	25	26	24	.0800	0
45	3	1	2	0	25	27	28	26	.0800	0
46	3	2	2	0	29	31	32	30	.1000	0
47	3	2	2	0	31	33	34	32	.1000	0
48	3	2	2	0	33	35	36	34	.1000	0
49	3	2	2	0	35	37	38	36	.1000	0
50	3	2	2	0	37	39	40	38	.1000	0
51	3	2	2	0	39	41	42	40	.1000	0
52	3	1	2	0	43	45	46	44	.1000	0
53	3	1	2	0	45	47	48	46	.1000	0
54	3	1	2	0	47	49	50	48	.1000	0
55	3	1	2	0	49	51	52	50	.1000	0
56	3	1	2	0	51	53	54	52	.1000	0
57	3	1	2	0	53	55	56	54	.1000	0
58	3	1	2	0	1	15	16	2	.1600	0
59	3	1	2	0	15	29	30	16	.1600	0
60	3	1	2	0	29	43	44	30	.1600	0
61	3	1	2	0	3	17	18	4	.0800	0
62	3	1	2	0	17	31	32	18	.0800	0
63	3	1	2	0	31	45	46	32	.0800	0
64	3	1	2	0	5	19	20	6	.0800	0
65	3	1	2	0	19	33	34	20	.0800	0
66	3	1	2	0	33	47	48	34	.0800	0
67	3	1	2	0	7	21	22	8	.0800	0
68	3	1	2	0	21	35	36	22	.0800	0
69	3	1	2	0	35	49	50	36	.0800	0
70	3	1	2	0	9	23	24	10	.0800	0
71	3	1	2	0	23	37	38	24	.0800	0
72	3	1	2	0	37	51	52	38	.0800	0
73	3	1	2	0	11	25	26	12	.0800	0
74	3	1	2	0	25	39	40	26	.0800	0
75	3	1	2	0	39	53	54	40	.0800	0
76	3	1	2	0	27	41	42	28	.0800	0
77	3	1	2	0	41	55	56	42	.0800	0

Figure 3.4.2. (continued).

INPUT FOR ELEMENT TYPE 4   THREE-DIMENSIONAL TRUSS ELEMENTS

MATERIAL PROPERTIES

MATL	MODULUS	DENSITY	YIELD	MX.INC.STRAIN	GAMMA	HARDENING	S-E CURVE
1	.10000E+08	.000259					
2	.30000E+08	.000725					

ELEMENT CONNECTIVITY   THREE-DIMENSIONAL TRUSS ELEMENTS

ELEM	MATL	KGEN	NODE-1	NODE-2	AREA
1	1	0	1	3	.10000
2	1	0	2	4	.10000
3	1	0	3	5	.10000
4	1	0	4	6	.10000
5	1	0	5	7	.10000
6	1	0	6	8	.10000
7	1	0	7	9	.10000
8	1	0	8	10	.10000
9	1	0	9	11	.10000
10	1	0	10	12	.10000
11	1	0	15	17	.15000
12	1	0	16	18	.15000
13	1	0	17	19	.15000
14	1	0	18	20	.15000
15	1	0	19	21	.15000
16	1	0	20	22	.15000
17	1	0	21	23	.15000
18	1	0	22	24	.15000
19	1	0	23	25	.15000
20	1	0	24	26	.15000
21	1	0	25	27	.15000
22	1	0	26	28	.15000
23	1	0	29	31	.10000
24	1	0	30	32	.10000
25	1	0	31	33	.10000
26	1	0	32	34	.10000
27	1	0	33	35	.16000
28	1	0	34	36	.16000
29	1	0	35	37	.28000
30	1	0	36	38	.28000
31	1	0	37	39	.28000
32	1	0	38	40	.28000
33	1	0	39	41	.14000
34	1	0	40	42	.14000
35	1	0	43	45	.10000
36	1	0	44	46	.10000
37	1	0	45	47	.10000
38	1	0	46	48	.10000
39	1	0	47	49	.10000
40	1	0	48	50	.12500
41	1	0	49	51	.11500
42	1	0	50	52	.14500
43	1	0	51	53	.12500
44	1	0	52	54	.17500
45	1	0	53	55	.10000
46	1	0	54	56	.12500
47	1	0	1	15	.10000

Figure 3.4.2. (continued).

48	1	0	2	16	.15000
49	1	0	15	29	.10000
50	1	0	16	30	.15000
51	1	0	29	43	.10000
52	1	0	30	44	.15000
53	1	0	3	17	.10000
54	1	0	4	18	.15000
55	1	0	17	31	.10000
56	1	0	18	32	.15000
57	1	0	31	45	.10000
58	1	0	32	46	.15000
59	1	0	5	19	.10000
60	1	0	6	20	.15000
61	1	0	19	33	.10000
62	1	0	20	34	.15000
63	1	0	33	47	.10000
64	1	0	34	48	.15000
65	1	0	7	21	.10000
66	1	0	8	22	.15000
67	1	0	21	35	.10000
68	1	0	22	36	.15000
69	1	0	35	49	.10000
70	1	0	36	50	.15000
71	1	0	9	23	.10000
72	1	0	10	24	.15000
73	1	0	23	37	.10000
74	1	0	24	38	.15000
75	1	0	37	51	.10000
76	1	0	38	52	.15000
77	1	0	11	25	.10000
78	1	0	12	26	.15000
79	1	0	25	39	.10000
80	1	0	26	40	.15000
81	1	0	39	53	.10000
82	1	0	40	54	.15000
83	1	0	27	41	.10000
84	1	0	28	42	.15000
85	1	0	41	55	.10000
86	1	0	42	56	.15000
87	1	0	1	2	.08000
88	1	0	3	4	.08000
89	1	0	5	6	.08000
90	1	0	7	8	.08000
91	1	0	9	10	.08000
92	1	0	11	12	.08000
93	1	0	15	16	.08000
94	1	0	17	18	.08000
95	1	0	19	20	.08000
96	1	0	21	22	.08000
97	1	0	23	24	.08000
98	1	0	25	26	.08000
99	1	0	27	28	.08000
100	1	0	29	30	.08000
101	1	0	31	32	.08000
102	1	0	33	34	.08000
103	1	0	35	36	.08000
104	1	0	37	38	.08000
105	1	0	39	40	.08000
106	1	0	41	42	.08000
107	1	0	43	44	.08000
108	1	0	45	46	.08000
109	1	0	47	48	.08000
110	1	0	49	50	.08000
111	1	0	51	52	.08000
112	1	0	53	54	.08000
113	1	0	55	56	.08100

Figure 3.4.2. (continued).

```
T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
  CASE 4 - FIRST TEST


BOUNDARY CONDITIONS

DEGREES OF FREEDOM PER NODE.....        3
UNCONSTRAINED NODAL CODE........        7
MAXIMUM PACKING CODE (MAXKOD)...        4

NUMBER OF TYPE 1 CONSTRAINTS....        1
NUMBER OF TYPE 2 CONSTRAINTS....        1
NUMBER OF TYPE 3 CONSTRAINTS....        0
NUMBER OF LINEAR CONSTRAINTS....        0
MAX NUMBER TERMS/CONSTRAINT.....        0

TYPE 1 CONSTRAINTS

NODE    1  THRU   16  BY   1    COMPONENTS    1    2    3    0    0    0    0    0    0    0

TYPE 2 CONSTRAINTS

COMPONENTS     1    2    3    0    0    0    0    0    0    0
NODE POINTS   25   26   27   28    0    0    0    0    0    0
```

Figure 3.4.2. (continued).

T38 WING / LINEAR ANALYSIS / MODEL DEVELOPMENT
CASE 4 - FIRST TEST

NODAL VARIABLF TABLES

NODE	NFDF	CODE	1	2	3
1	1	0	0	0	0
2	1	0	0	0	0
3	1	0	0	0	0
4	1	0	0	0	0
5	1	0	0	0	0
6	1	0	0	0	0
7	1	0	0	0	0
8	1	0	0	0	0
9	1	0	0	0	0
10	1	0	0	0	0
11	1	0	0	0	0
12	1	0	0	0	0
13	1	0	0	0	0
14	1	0	0	0	0
15	1	0	0	0	0
16	1	0	0	0	0
17	1	7	1	2	3
18	4	7	4	5	6
19	7	7	7	8	9
20	10	7	10	11	12
21	13	7	13	14	15
22	16	7	16	17	18
23	19	7	19	20	21
24	22	7	22	23	24
25	25	0	0	0	0
26	25	0	0	0	0
27	25	0	0	0	0
28	25	0	0	0	0
29	25	7	25	26	27
30	29	7	28	29	30
31	31	7	31	32	33
32	34	7	34	35	36
33	37	7	37	38	39
34	40	7	40	41	42
35	43	7	43	44	45
36	46	7	46	47	48
37	49	7	49	50	51
38	52	7	52	53	54
39	55	7	55	56	57
40	58	7	58	59	60
41	61	7	61	62	63
42	64	7	64	65	66
43	67	7	67	68	69
44	70	7	70	71	72
45	73	7	73	74	75
46	76	7	76	77	78
47	79	7	79	80	81
48	82	7	82	83	84
49	85	7	85	86	87
50	88	7	88	89	90
51	91	7	91	92	93
52	94	7	94	95	96

Figure 3.4.2. (continued).

```
53   97    7    97   98   99
54  100    7   100  101  102
55  103    7   103  104  105
56  106    7   106  107  108

     T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
       CASE  4 - FIRST TEST


MATRIX PARTITIONING DATA :

DEGREES OF FREEDOM . . . .        108
NUMBER OF PARTITIONS . . .          1
MAXIMUM PARTITION SIZE . .       3591
WORK AREA AVAILABLE  . . .      12000
WORK AREA USED . . . . . .       7290

MAXIMUM HALF-BANDWIDTH . .         51
AVERAGE HALF-BANDWIDTH . .         34
APPARENT POPULATION  . .         3591
```

Figure 3.4.2. (continued).

T3A WING / LINEAR ANALYSIS / MODEL DEVELOPMENT
CASE 4 - FIRST TEST

MATRIX PROFILE MAP

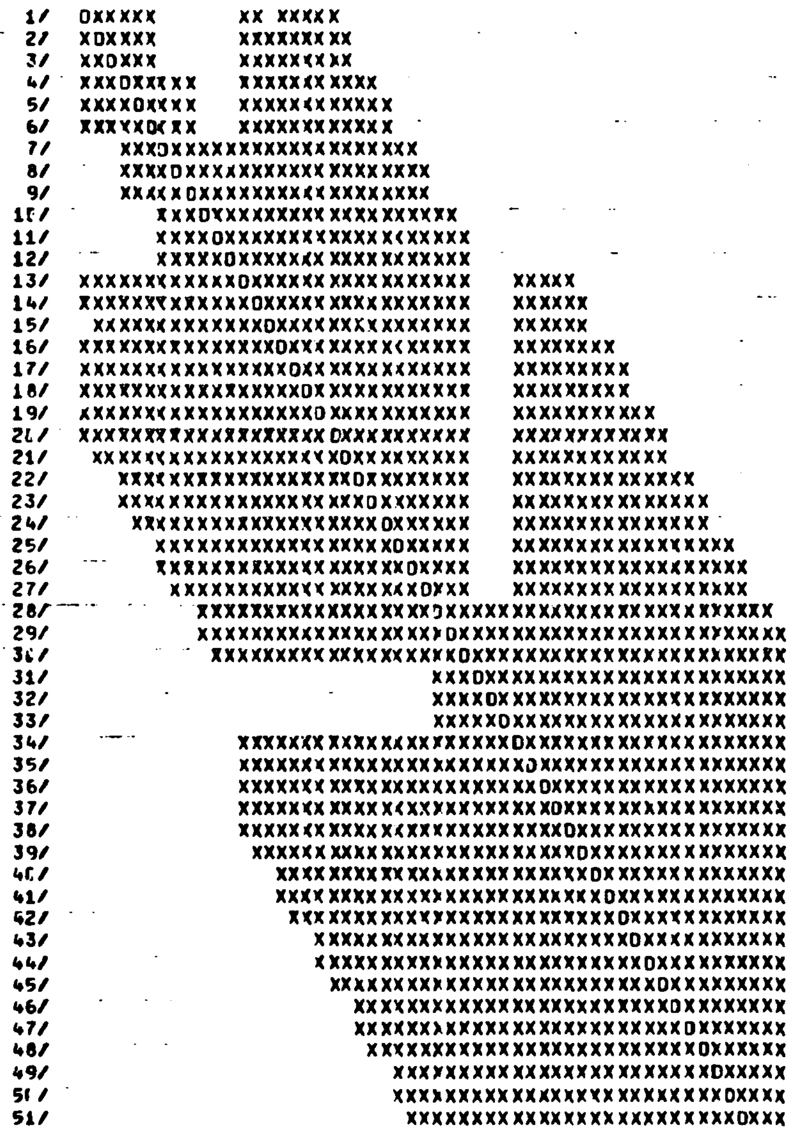


Figure 3.4.2. (continued).

```
52/                              XXXXXXXXXXXXXXXXXXXXXXXXXXDXX
53/                              XXXXXXXXXXXXXXXXXXXXXXXXXXXDX
54/                               XXXXXXXXXXXXXXXXXXXXXXXXXXXD

SCALE  :  X =MATRIX OF DIMENSION      2
```

Figure 3.4.2. (continued).

T38 WING / LINEAR ANALYSIS / MODEL DEVELOPMENT
CASE 4 = FIRST TEST

DIRECT NODAL LOADS INPUT

DEGREES OF FREEDOM....... 108
LOAD CASES............... 1
VECTORS PER RECORD....... 1

CASE	NODE	COMPT	DOF	VALUE
1	43	1	67	31.4700
1	43	2	68	2058.6300
1	43	3	69	142.1300
1	44	1	70	-31.4700
1	44	2	71	-2058.6300
1	44	3	72	142.1300
1	45	1	73	73.2100
1	45	2	74	4788.6100
1	45	3	75	-143.0000
1	46	1	76	-73.2100
1	46	2	77	-4788.6100
1	46	3	78	-143.0000
1	47	1	79	84.2000
1	47	2	80	5507.6400
1	47	3	81	39.5100
1	48	1	82	-84.2000
1	48	2	83	-5507.6400
1	48	3	84	39.5100
1	49	1	85	96.2000
1	49	2	86	6292.5400
1	49	3	87	252.5600
1	50	1	88	-96.2000
1	50	2	89	-6292.5400
1	50	3	90	252.5600
1	51	1	91	99.8200
1	51	2	92	6529.2500
1	51	3	93	505.6500
1	52	1	94	-99.8200
1	52	2	95	-6529.2500
1	52	3	96	505.6500
1	53	1	97	250.2700
1	53	2	98	16370.3000
1	53	3	99	906.0300
1	54	1	100	-250.2700
1	54	2	101	-16370.3000
1	54	3	102	906.0300
1	55	1	103	148.3200
1	55	2	104	9701.8000
1	55	3	105	2415.5800
1	56	1	106	-148.3200
1	56	2	107	-9701.8000
1	56	3	108	2415.5800

END OF LOADS PROCESSING

Figure 3.4.2. (continued).

END OF ELEMENT PROCESSING

T38 WING / LINEAR ANALYSIS / MODEL DEVELOPMENT
CASE 4 - FIRST TEST

LOAD CASE 1
DISPLACEMENTS (TOTAL) AT INCREMENT 1 TIME = 0.

NODE	-- U --	-- V --	-- W --
1	0.00000000 *	0.00000000 *	0.00000000 *
2	0.00000000 *	0.00000000 *	0.00000000 *
3	0.00000000 *	0.00000000 *	0.00000000 *
4	0.00000000 *	0.00000000 *	0.00000000 *
5	0.00000000 *	0.00000000 *	0.00000000 *
6	0.00000000 *	0.00000000 *	0.00000000 *
7	0.00000000 *	0.00000000 *	0.00000000 *
8	0.00000000 *	0.00000000 *	0.00000000 *
9	0.00000000 *	0.00000000 *	0.00000000 *
10	0.00000000 *	0.00000000 *	0.00000000 *
11	0.00000000 *	0.00000000 *	0.00000000 *
12	0.00000000 *	0.00000000 *	0.00000000 *
13	0.00000000 *	0.00000000 *	0.00000000 *
14	0.00000000 *	0.00000000 *	0.00000000 *
15	0.00000000 *	0.00000000 *	0.00000000 *
16	0.00000000 *	0.00000000 *	0.00000000 *
17	.00105006	.00166241	.00638615
18	-.00118978	-.04213528	.00613542
19	.00141135	.00258219	.00973141
20	-.00159327	-.00294733	.00958429
21	.00135586	.00288822	.01040753
22	-.00154064	-.00329359	.01025140
23	.00087155	.00250449	.00770130
24	-.00099703	-.00286303	.00725881
25	0.00000000 *	0.00000000 *	0.00000000 *
26	0.00000000 *	0.00000000 *	0.00000000 *
27	0.00000000 *	0.00000000 *	0.00000000 *
28	0.00000000 *	0.00000000 *	0.00000000 *
29	.00331717	.00637438	.09787333
30	-.00352503	-.00713769	.09976141
31	.00319069	.00675694	.11113616
32	-.00336503	-.00757039	.11261150
33	.00314326	.00769619	.12253325
34	-.00330024	-.00861521	.12368090
35	.00316178	.00892186	.13241188
36	-.00329972	-.00995844	.13320638
37	.00330406	.01042325	.14114156
38	-.00343205	-.01157850	.14174255
39	.00327770	.01141795	.14786599
40	-.00342077	-.01269596	.14850641
41	.00190330	.01204719	.17771711
42	-.00260983	-.01378851	.17856578
43	.00576062	.00699474	.38009535
44	-.00599140	-.00783545	.38041354
45	.00694019	.00855216	.40156669
46	-.00726589	-.00950050	.40209745
47	.00829044	.01008033	.42672541
48	-.00872331	-.01113447	.42752573
49	.00974724	.01188386	.45522595

Figure 3.4.2. (continued).

50	-.01030449	-.01308234	.45619642
51	.01123340	.01407517	.48672256
52	-.01191781	-.01548737	.48748832
53	.01196668	.01582641	.51481226
54	-.01274317	-.01749326	.51495267
55	.01094364	.01699975	.64607008
56	-.01192274	-.01936076	.64561812

Figure 3.4.2. (continued).

```
T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
  CASE 4 - FIRST TEST


ELEMENT STRESSES FOR LOAD CASE      1
INCREMENT     1       T =           0.000000
```

Figure 3.4.2. (continued).

T38 WING / LINEAR ANALYSIS / MODEL DEVELOPMENT
CASE 4 - FIRST TEST

ELEMENT STRESSES FOR TWO-DIMENSIONAL PLANE STRESS, PLANE STRAIN, AND SHEAR PANEL ELEMENTS

ELEMENT	INT.PT	STRAIN(XX)	STRAIN(YY)	STRAIN(XY)	STRESS(XX)	STRESS(YY)	STRESS(XY)	STRESS(MAX)	STRESS(MIN)
1	1	.31385E-04	.13222E-04	.68605E-04	.38848E+03	.24877E+03	.26387E+03	.59150E+03	.45667E+02
1	2	.11662E-03	.13164E-04	.23668E-03	.13249E+04	.52911E+03	.91030E+03	.19285E+04	-.66455E+02
1	3	.31976E-04	.50274E-04	.88556E-04	.51712E+03	.65788E+03	.34060E+03	.93529E+03	.23970E+03
1	4	.11880E-03	.50049E-04	.25969E-03	.14705E+04	.94164E+03	.99880E+03	.22393E+04	.17206E+03
2	1	-.36166E-04	-.15159E-04	-.78696E-04	-.44741E+03	-.28581E+03	-.30268E+03	-.53337E+02	-.67988E+03
2	2	-.13438E-03	-.15193E-04	-.27139E-03	-.15265E+04	-.60887E+03	-.10438E+04	.72530E+02	-.22079E+04
2	3	-.36847E-04	-.57640E-04	-.10168E-03	-.59493E+03	-.75488E+03	-.39107E+03	-.27574E+03	-.10741E+04
2	4	-.13690E-03	-.57382E-04	-.29788E-03	-.16936E+04	-.10819E+04	-.11457E+04	-.20189E+03	-.25735E+04
3	1	.11084E-04	.69989E-04	.60772E-04	.35253E+03	.80565E+03	.23374E+03	.90461E+03	.25357E+03
3	2	.41286E-04	.69850E-04	.13081E-03	.68440E+03	.90380E+03	.50310E+03	.13089E+04	.27894E+03
3	3	.11301E-04	.86081E-04	.68210E-04	.40797E+03	.98320E+03	.26235E+03	.10849E+04	.30629E+03
3	4	.42094E-04	.85919E-04	.13960E-03	.74582E+03	.13829E+04	.53692E+03	.14771E+04	.35161E+03
4	1	-.12750E-04	-.80147E-04	-.69441E-04	-.40434E+03	-.92277E+03	-.26708E+03	-.29136E+03	-.10357E+04
4	2	-.47494E-04	-.80061E-04	-.14855E-03	-.78566E+03	-.10357E+04	-.57135E+03	-.32581E+03	-.14956E+04
4	3	-.13000E-04	-.98325E-04	-.77987E-04	-.46701E+03	-.11234E+04	-.29995E+03	-.35058E+03	-.12398E+04
4	4	-.48424E-04	-.98141E-04	-.15863E-03	-.85567E+03	-.12381E+04	-.61011E+03	-.40752E+03	-.16863E+04
5	1	-.75590E-06	.95168E-04	.57324E-04	.30543E+03	.10433E+04	.22048E+03	.11042E+04	.24457E+03
5	2	-.28214E-05	.95082E-04	.92515E-04	.28245E+03	.10356E+04	.35583E+03	.11771E+04	.14093E+03
5	3	-.77136E-06	.10360E-03	.57093E-04	.33306E+03	.11359E+04	.21959E+03	.11920E+04	.27692E+03
5	4	-.28791E-05	.10351E-03	.93004E-04	.30961E+03	.11280E+04	.35771E+03	.12623E+04	.17531E+03
6	1	.62050E-06	-.10866E-03	-.65851E-04	-.35121E+03	-.11914E+04	-.25327E+03	-.28076E+03	-.12618E+04
6	2	.23160E-05	-.10850E-03	-.10575E-03	-.33226E+03	-.11847E+04	-.40672E+03	-.16934E+03	-.13476E+04
6	3	.63319E-06	-.11816E-03	-.65743E-04	-.38258E+03	-.12964E+04	-.25286E+03	-.31728E+03	-.13617E+04
6	4	.23634E-05	-.11816E-03	-.10645E-03	-.36324E+03	-.12896E+04	-.40944E+03	-.20822E+03	-.14446E+04
7	1	-.12824E-04	.10462E-03	.31638E-04	.20399E+03	.11074E+04	.12168E+03	.11235E+04	.18789E+03
7	2	-.47954E-04	.10468E-03	.70107E-05	-.18188E+03	.99222E+03	.26964E+02	.99284E+03	-.18249E+03
7	3	-.13099E-04	.98425E-04	.22630E-04	.18054E+03	.10384E+04	.87038E+02	.10472E+04	.17188E+03
7	4	-.48983E-04	.98469E-04	-.25435E-05	-.21366E+03	.92059E+03	-.97826E+01	.92067E+03	-.21374E+03
8	1	.14333E-04	-.11936E-03	-.37161E-04	-.23600E+03	-.12644E+04	-.14293E+03	-.21650E+03	-.12839E+04

Figure 3.4.2. (continued).

T38 WING / LINEAR ANALYSIS / MODEL DEVELOPMENT
CASE 4 - FIRST TEST

ELEMENT STRESSES FOR TWO-DIMENSIONAL PLANE STRESS, PLANE STRAIN, AND SHEAR PANEL ELEMENTS

ELEMENT	INT. PT	STRAIN(XX)	STRAIN(YY)	STRAIN(XY)	STRESS(XX)	STRESS(YY)	STRESS(XY)	STRESS(MAX)	STRESS(MIN)
8	2	.53596E-04	-.11942E-03	-.96966E-05	.19527E+03	-.11356E+04	-.37294E+02	.19631E+03	-.11367E+04
8	3	.14640E-04	-.11245E-03	-.27094E-04	-.20983E+03	-.11874E+04	-.10421E+03	-.19885E+03	-.11984E+04
8	4	.54746E-04	-.11250E-03	.97993E-06	.23074E+03	-.10558E+04	.37689E+01	.23075E+03	-.10558E+04
9	1	-.33091E-04	.76380E-04	-.65797E-04	-.11163E+03	.73825E+03	-.25307E+03	.80045E+03	-.18203E+03
9	2	-.12400E-03	.76691E-04	-.32113E-03	-.11098E+04	.43398E+03	-.12351E+04	.11186E+04	-.17944E+04
9	3	-.33780E-04	.20843E-04	-.87275E-04	-.30162E+03	.11794E+03	-.33567E+03	.30400E+03	-.48767E+03
9	4	-.12629E-03	.20929E-04	-.34742E-03	-.13188E+04	-.18635E+03	-.13362E+04	.69865E+03	-.22038E+04
10	1	.37742E-04	-.67315E-04	.75287E-04	.12698E+03	-.83538E+03	.28957E+03	.20734E+03	-.91552E+03
10	2	.14143E-03	-.87671E-04	.36717E-03	.12651E+04	-.49716E+03	.14122E+04	.20485E+04	-.12806E+04
10	3	.38437E-04	-.23827E-04	.99788E-04	.34384E+03	-.13512E+03	.38386E+03	.55675E+03	-.34803E+03
10	4	.14405E-03	-.23926E-04	.39717E-03	.15040E+04	.21195E+03	.15276E+04	.25166E+04	-.80050E+03
11	1	.70437E-04	.14127E-03	.28280E-03	.12397E+04	.17846E+04	.10877E+04	.26335E+04	.39086E+03
11	2	-.34473E-04	.18516E-03	.18756E-03	.23161E+03	.19211E+04	.72137E+03	.21872E+04	-.34483E+02
11	3	.70824E-04	.12283E-03	.26847E-03	.11832E+04	.15832E+04	.10326E+04	.24350E+04	.33146E+03
11	4	-.32504E-04	.16383E-03	.17222E-03	.18829E+03	.16844E+04	.66238E+03	.19345E+04	-.69818E+02
12	1	-.82417E-04	-.14977E-03	-.31657E-03	-.13994E+04	-.19175E+04	-.12176E+04	-.41363E+03	-.29033E+04
12	2	.35078E-04	-.20132E-03	-.20280E-03	-.27820E+03	-.20966E+04	-.78001E+03	.10536E+02	-.23854E+04
12	3	-.82851E-04	-.12811E-03	-.30054E-03	-.13328E+04	-.16810E+04	-.11559E+04	-.33794E+03	-.26758E+04
12	4	.32873E-04	-.17533E-03	-.18576E-03	-.21676E+03	-.18183E+04	-.71446E+03	.55633E+02	-.20907E+04
13	1	.12680E-04	.16024E-03	.12704E-03	.66762E+03	.18027E+04	.48861E+03	.19841E+04	.48626E+03
13	2	-.45680E-04	.14711E-03	.18872E-03	-.17004E+02	.14660E+04	.72585E+03	.17621E+04	-.31314E+03
13	3	.12892E-04	.16643E-03	.11875E-03	.69035E+03	.18714E+04	.45671E+03	.20274E+04	.53435E+03
13	4	-.44605E-04	.15458E-03	.17819E-03	.19187E+02	.15508E+04	.68533E+03	.18127E+04	-.24278E+03
14	1	-.15751E-04	-.17086E-03	-.13948E-03	-.73636E+03	-.19295E+04	-.53647E+03	-.53061E+03	-.21352E+04
14	2	.48636E-04	-.15756E-03	-.20351E-03	.15054E+02	-.15711E+04	-.78272E+03	.33627E+03	-.18922E+04
14	3	-.15985E-04	-.17713E-03	-.13035E-03	-.75959E+03	-.19991E+04	-.50133E+03	-.58221E+03	-.21765E+04
14	4	.47451E-04	-.16504E-03	-.19196E-03	-.22664E+02	-.16572E+04	-.73830E+03	.26143E+03	-.19413E+04
15	1	-.24110E-04	.18623E-03	.64271E-04	.34899E+03	.19670E+04	.24720E+03	.20039E+04	.31207E+03
15	2	-.48866E-04	.15632E-03	.18751E-03	-.21651E+02	.15567E+04	.72119E+03	.18366E+04	-.30155E+03
15	3	-.24022E-04	.20233E-03	.60444E-04	.40304E+03	.21442E+04	.23248E+03	.21747E+04	.37253E+03
15	4	-.48418E-04	.17546E-03	.18134E-03	.46364E+02	.17685E+04	.69747E+03	.20155E+04	-.20868E+03

Figure 3.4.2. (continued).

T38 WING / LINEAR ANALYSIS / MODEL DEVELOPMENT
CASE 4 = FIRST TEST

MAXIMUM EFFECTIVE STRESS LEVELS FOR TYPE 3 ELEMENTS

MATERIAL	CRITICAL ELEMENT	VON MISES STRESS
1	76	.54024954E+05
2	50	.14787567E+05

Figure 3.4.2. (continued).

T38 WING / LINEAR ANALYSIS / MODEL DEVELOPMENT
CASE 4 - FIRST TEST

ELEMENT STRESSES FOR THREE-DIMENSIONAL TRUSS ELEMENTS

ELEMENT	MODULUS	AREA	LENGTH	STRAIN	STRESS	TOTAL FORCE
1	.1000000E+08	.1000000E+00	.6390874E+01	0.	0.	0.
2	.1000000E+08	.1000000E+00	.6390874E+01	0.	0.	0.
3	.1000000E+08	.1000000E+00	.6460884E+01	0.	0.	0.
4	.1000000E+08	.1000000E+00	.6460884E+01	0.	0.	0.
5	.1000000E+08	.1000000E+00	.6530893E+01	0.	0.	0.
6	.1000000E+08	.1000000E+00	.6530893E+01	0.	0.	0.
7	.1000000E+08	.1000000E+00	.6610905E+01	0.	0.	0.
8	.1000000E+08	.1000000E+00	.6610905E+01	0.	0.	0.
9	.1000000E+08	.1000000E+00	.5560820E+01	0.	0.	0.
10	.1000000E+08	.1000000E+00	.5560820E+01	0.	0.	0.
11	.1000000E+08	.1500000E+00	.6509514E+01	.1016635E-03	.1016635E+04	.1524953E+03
12	.1000000E+08	.1500000E+00	.6509514E+01	-.1173903E-03	-.1173903E+04	-.1760854E+03
13	.1000000E+08	.1500000E+00	.6551068E+01	.3007425E-04	.3007425E+03	.4511138E+02
14	.1000000E+08	.1500000E+00	.6551068E+01	-.3494219E-04	-.3494219E+03	-.5241328E+02
15	.1000000E+08	.1500000E+00	.6598183E+01	-.1671779E-04	-.1671779E+03	-.2507668E+02
16	.1000000E+08	.1500000E+00	.6598183E+01	.1796755E-04	.1796755E+03	.2695133E+02
17	.1000000E+08	.1500000E+00	.6657928E+01	-.5702433E-04	-.5702433E+03	-.8553649E+02
18	.1000000E+08	.1500000E+00	.6657928E+01	.6395356E-04	.6395356E+03	.9593034E+02
19	.1000000E+08	.1500000E+00	.5579133E+01	-.9292002E-04	-.9292002E+03	-.1393800E+03
20	.1000000E+08	.1500000E+00	.5579133E+01	.1058077E-03	.1058077E+04	.1587116E+03
21	.1000000E+08	.1500000E+00	.2693277E+02	0.	0.	0.
22	.1000000E+08	.1500000E+00	.2693277E+02	0.	0.	0.

Figure 3.4.2. (continued).

```
T3A WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
  CASE 4 = FIRST TEST


MAXIMUM EFFECTIVE STRESS LEVELS FOR TYPE 4 ELEMENTS

MATERIAL   CRITICAL ELEMENT   VON MISES STRESS

   1            100             .68657344E+04
```

Figure 3.4.2. (continued).

```
T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
  CASE 4 - FIRST TEST


SOLUTION TIME SUMMARY

INPUT AND TABLE SETUP....          1.983
ELEMENT MATRICES.........          3.897
MATRIX ASSEMBLY..........           .327
MATRIX SOLUTION..........           .385
OUTPUT PHASE.............           .385
STRESS RECOVERY..........          2.590


SUMMARY OF SEQUENTIAL I/O OPERATIONS

READ REQUESTS.......................        2589
WRITE REQUESTS......................        1639
WORDS TRANSFERRED (INPUT)...........       38690
WORDS TRANSFERRED (OUTPUT)..........       25960
```

Figure 3.4.2. (continued).

```
CSB     NOS/BE L499C        L499C-CMR3 04/07/80
19.17.46.UD5U8QY  FROM CSA/U8
19.17.46.IP  00001664 WORDS - FILE INPUT  , DC 04
19.17.40.UD5K,T531,IO600,CM135000),STCSB, D770043,
19.17.40.BRUNER,KL565,93351-94
19.17.43.SET,R1=MFL.
19.18.05.COPYCR,INPUT,TAPE5.
19.18.06.REQUEST,MPOST,*PF.
19.18.06.ATTACH,P,MAGNAJCL,ID=BROCKMAN.
19.18.07.PF CYCLE NO. = 998
19.18.07.BEGIN,XMAGNA,P,MAIN,,R1+3.
19.18.09.ATTACH,Q0000),TITLE,ID=BROCKMAN,SN=AFFDL
19.18.09..
19.18.10.PF CYCLE NO. = 001
19.18.10.COPYBF,Q0000),OUTPUT.
19.18.10.EOI ENCOUNTERED AFTER COPY OF FILE
19.18.10.          0, RECORD  1
19.18.10.RETURN,Q0000).
19.18.10.SET,R2=0.
19.18.11.SET,R3=0.
19.18.11.IFE,NUM(MAIN)=0,SKIPM.
19.18.12.SET,R2=1.
19.18.12.ATTACH,UPDGEN,MAGNAUPDGEN,CY=2,ID=BROCKM
19.18.12.AN,SN=AFFDL.
19.18.12.UPDGEN.
19.18.21.    STOP
19.18.21.       .172 CP  SECONDS EXECUTION TIME
19.18.21.RETURN,UPDGEN.
19.18.22.REWIND,MODS.
19.18.22.ATTACH,OLDPL,RABDRIVER,CY=1,ID=BROCKMAN,
19.18.22.SN=AFFDL.
19.18.22.UPDATE,P,I=MODS,L=0,R=C.
19.18.24. UPDATE COMPLETE.
19.18.24.RETURN,MODS.
19.18.24.FTN,I,OPT=2,B=MAIN,L,R=1,PL=999999.
19.20.10.       .436 CP  SECONDS COMPILATION TIME
19.20.10.RETURN,OLDPL,COMPILE.
19.20.11.ENDIF,SKIPM.
19.20.11.IFE,NUM(0)=0,SKIPU.
19.20.11.ENDIF,SKIPU.
19.20.11.IFE,R2.EQ.0.AND.R3.EQ.0,GO.
19.20.12.ELSE,GO.
19.20.12.ATTACH,TEMP,MAGNALGO,CY=2,ID=BROCKMAN,SN
19.20.12.=AFFDL,MR=1.
19.20.12.ENDIF,GO.
19.20.12.IFE,R2.GT.0.AND.R3.GT.0,COPYA.
19.20.14.ENDIF,COPYA.
19.20.14.IFE,R2.GT.0.AND.R3.EQ.0,COPYB.
19.20.14.REWIND,TEMP,MAIN,MAGNA.
19.20.15.COPYLM,TEMP,MAIN,MAGNA,,A.
19.20.15. UPDATED -- REL    / MAIN
19.20.22. COPYL COMPLETE.
19.20.23.RETURN,TEMP,MAIN.
19.20.23.ENDIF,COPYB.
19.20.24.IFE,R2.EQ.0.AND.R3.GT.0,COPYC.
19.20.24.ENDIF,COPYC.
19.20.24.IFE,FILE(TAPE5,AS),GETDATA.
19.20.25.**************************
19.20.25.***** TAPE5 = LOCAL *****
19.20.25.**************************
19.20.25.ELSE,GETDATA.
19.20.26.ENDIF,GETDATA.
```

Figure 3.4.2. (continued).

```
19.20.26.REWIND,TAPE5.
19.20.26.COPYSBF,TAPE5,OUTPUT.
19.20.27.REWIND,TAPE5.
19.20.27.ATTACH,UPDIN,MAGNALGO,CY=4,ID=BROCKMAN,S
19.20.27.N=AFFOL.
19.20.58.UPDATE,N,I=UPDIN,C=SEGL00,D,8,R=C,L=C.
19.20.59.UPDATE CREATION RUN
19.20.59.CREATING NEW PROGRAM LIBRARY
19.21.00. UPDATE COMPLETE.
19.21.00.RETURN,NEWPL,UPDIN.
19.21.00.REWIND,MAGNA.
19.21.00.LIMIT,7777.
19.21.00.RFL,135000.
19.21.00.SUMMARY.
19.21.01.MS    71680 WORDS (   75264 MAX USED)
19.21.01.CPA       2.673 SEC.       1.338 ADJ.
19.21.01.IO       33.215 SEC.      18.800 ADJ.
19.21.01.CM      246.995 KWS.       2.005 ADJ.
19.21.01.CRUS                      22.144
19.21.01.COST                 $     1.01
19.21.01.PP       30.233 SEC.    DATE 05/15/80
19.21.01.LDSET(MAP=S/ERRORS)
19.21.02.SEGLOAD(I=SEGLOD)
19.21.02.MAGNA.
19.39.13.     NON-FATAL LOADER ERRORS - SEE MAP
19.41.18.    STOP
19.41.18.     9.078 CP SECONDS EXECUTION TIME
19.41.18.REVERT.
19.41.19.CATALOG,MPOST,WINGMPOST,RP=600.
19.41.19.NEWCYCLE CATALOG
19.41.19.CT ID=  D770143 PFN=WINGMPOST
19.41.19.CT CY= 010  00007488 WORDS.
19.41.19.OP  00015040 WORDS - FILE OUTPUT , DC 40
19.41.19.MS   28672 WORDS (  379904 MAX USED)
19.41.19.CPA      51.219 SEC.      25.639 ADJ.
19.41.19.IO      114.221 SEC.      64.649 ADJ.
19.41.19.CM     6100.644 KWS.      49.535 ADJ.
19.41.19.CRUS                     139.824
19.41.19.COST                 $     6.37
19.41.19.PP       48.419 SEC.    DATE 05/16/80
19.41.26.EJ  END OF JOB, U8  D770143.

***********        IJD5KBG  //// END OF LIST ////
***********        IJD5KBG  //// END OF LIST ////
```

Figure 3.4.2. (concluded).

3.5 MAGNA OUTPUT WINGMPOST POSTPROCESSOR FILE

In addition to the printed output tab of the problem solution MAGNA also produces a special file for postprocessing of the data by the programs CONTOUR and PLOTBOB. This file is listed in Figure 3.5.1. The file contains information essentially the same as on the printed tab but in a condensed format to save space on auxiliary (disk) storage. If the user is executing very large nonlinear problems with a large number of increments the WINGMPOST file should be written to a tape for storage rather than having it remain on disk. This will alleviate potential problems with losing the data file as a result of the ASD permanent file management system. All important files should be placed on tape at any rate, for insurance.

The user is cautioned against making any modifications to this output file as it will almost certainly result in errors while trying to be utilized by CONTOUR or PLOTBOB. It is important for the user to be certain that there is sufficient space available for the WINGMPOST file and that a free cycle number is available for the WINGMPOST permanent file name under the problem number to be used. If there is no available cycle position,the day file (Section 3.4.14) will give a message to that effect. If there is insufficient space available for your office the file will be automatically purged.

```
             T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
               CASE 5B - FIRST TEST
    1    1
   1  1  1  1  0  1  1  0  0  0  1  0  0  0  0  0  0  0  0  0
COOR            56
   1      0.00000+ 00.00000+ 0-.21600+ 1
   2      0.00000+ 00.00000+ 0 .21600+ 1
   3       .63900+ 10.00000+ 0-.22657+ 1
   4       .63900+ 10.00000+ 0 .22657+ 1
   5       .12850+ 20.00000+ 0-.23728+ 1
   6       .12850+ 20.00000+ 0 .23728+ 1
   7       .19300+ 20.00000+ 0-.24806+ 1
   8       .19300+ 20.00000+ 0 .24806+ 1
   9       .25900+ 20.00000+ 0-.25900+ 1
  10       .25900+ 20.00000+ 0 .25900+ 1
  11       .31550+ 20.00000+ 0-.25750+ 1
  12       .31550+ 20.00000+ 0 .25750+ 1
  13       .58480+ 20.00000+ 0-.21900+ 1
  14       .58480+ 20.00000+ 0 .21900+ 1
  15      0.00000+ 0 .29920+ 2-.21600+ 1
  16      0.00000+ 0 .29920+ 2 .21600+ 1
  17       .64386+ 1 .28968+ 2-.22664+ 1
  18       .64386+ 1 .28968+ 2 .22664+ 1
  19       .12918+ 2 .28000+ 2-.23734+ 1
  20       .12918+ 2 .28000+ 2 .23734+ 1
  21       .19445+ 2 .27044+ 2-.24812+ 1
  22       .19445+ 2 .27044+ 2 .24812+ 1
  23       .26030+ 2 .26070+ 2-.25900+ 1
  24       .26030+ 2 .26070+ 2 .25900+ 1
  25       .31550+ 2 .25260+ 2-.25750+ 1
  26       .31550+ 2 .25260+ 2 .25750+ 1
  27       .58480+ 2 .25230+ 2-.21900+ 1
  28       .58480+ 2 .25230+ 2 .21900+ 1
  29       .18140+ 2 .64800+ 2-.13750+ 1
  30       .18140+ 2 .64800+ 2 .13750+ 1
  31       .23423+ 2 .64800+ 2-.14994+ 1
  32       .23423+ 2 .64800+ 2 .14994+ 1
  33       .28716+ 2 .64800+ 2-.16241+ 1
  34       .28716+ 2 .64800+ 2 .16241+ 1
  35       .34027+ 2 .64800+ 2-.17492+ 1
  36       .34027+ 2 .64800+ 2 .17492+ 1
  37       .30370+ 2 .64800+ 2-.18750+ 1
  38       .30370+ 2 .64800+ 2 .18750+ 1
  39       .43830+ 2 .64800+ 2-.18750+ 1
  40       .43830+ 2 .64800+ 2 .18750+ 1
  41       .63860+ 2 .64800+ 2-.14600+ 1
  42       .63860+ 2 .64800+ 2 .14600+ 1
  43       .36820+ 2 .10100+ 3-.11700+ 1
  44       .36820+ 2 .10100+ 3 .11700+ 1
  45       .40600+ 2 .10100+ 3-.12628+ 1
  46       .40600+ 2 .10100+ 3 .12628+ 1
  47       .44370+ 2 .10100+ 3-.13650+ 1
  48       .44370+ 2 .10100+ 3 .13650+ 1
  49       .48140+ 2 .10100+ 3-.14474+ 1
  50       .48140+ 2 .10100+ 3 .14474+ 1
  51       .51920+ 2 .10100+ 3-.15400+ 1
  52       .51920+ 2 .10100+ 3 .15400+ 1
  53       .55060+ 2 .10100+ 3-.15400+ 1
  54       .55060+ 2 .10100+ 3 .15400+ 1
  55       .60270+ 2 .10100+ 3-.13100+ 1
```

Figure 3.5.1. MPOST file listing for the linear analysis of the T-38 wing model illustrated in Figure 3.4.2.

```
      56          .89270+ 2 .10100+ 3 .13100+ 1
CONN          3      4    77
       1    1    3   17   15    1
       2    2    4   18   16    1
       3    3    5   19   17    1
       4    4    6   20   18    1
       5    5    7   21   19    1
       6    6    8   22   20    1
       7    7    9   23   21    1
       8    8   10   24   22    1
       9    9   11   25   23    1
      10   10   12   26   24    1
      11   15   17   31   29    1
      12   16   18   32   30    1
      13   17   19   33   31    1
      14   18   20   34   32    1
      15   19   21   35   33    1
      16   20   22   36   34    1
      17   21   23   37   35    1
      18   22   24   38   36    1
      19   23   25   39   37    1
      20   24   26   40   38    1
      21   25   27   41   39    1
      22   26   28   42   40    1
      23   29   31   45   43    1
      24   30   32   46   44    1
      25   31   33   47   45    1
      26   32   34   48   46    1
      27   33   35   49   47    1
      28   34   36   50   48    1
      29   35   37   51   49    1
      30   36   38   52   50    1
      31   37   39   53   51    1
      32   38   40   54   52    1
      33   39   41   55   53    1
      34   40   42   56   54    1
      35    1    3    4    2    3
      36    3    5    6    4    3
      37    5    7    8    6    3
      38    7    9   10    8    3
      39    9   11   12   10    3
      40   15   17   18   16    3
      41   17   19   20   18    3
      42   19   21   22   20    3
      43   21   23   24   22    3
      44   23   25   26   24    3
      45   25   27   28   26    3
      46   29   31   32   30    3
      47   31   33   34   32    3
      48   33   35   36   34    3
      49   35   37   38   36    3
      50   37   39   40   38    3
      51   39   41   42   40    3
      52   43   45   46   44    3
      53   45   47   48   46    3
      54   47   49   50   48    3
      55   49   51   52   50    3
      56   51   53   54   52    3
      57   53   55   56   54    3
      58    1   15   16    2    3
      59   15   29   30   16    3
      60   29   43   44   30    3
      61    3   17   18    4    3
      62   17   31   32   18    3
```

Figure 3.5.1. (continued).

```
  63   31   45   46   32    3
  64    5   19   20    6    3
  65   19   33   34   20    3
  66   33   47   48   34    3
  67    7   21   22    8    3
  68   21   35   36   22    3
  69   35   49   50   36    3
  70    9   23   24   10    3
  71   23   37   38   24    3
  72   37   51   52   38    3
  73   11   25   26   12    3
  74   25   39   40   26    3
  75   39   53   54   40    3
  76   27   41   42   28    3
  77   41   55   56   42    3
CONN        4    2  113
   1    1    3
   2    2    4
   3    3    5
   4    4    6
   5    5    7
   6    6    8
   7    7    9
   8    8   10
   9    9   11
  10   10   12
  11   15   17
  12   16   18
  13   17   19
  14   18   20
  15   19   21
  16   20   22
  17   21   23
  18   22   24
  19   23   25
  20   24   26
  21   25   27
  22   26   28
  23   29   31
  24   30   32
  25   31   33
  26   32   34
  27   33   35
  28   34   36
  29   35   37
  30   36   38
  31   37   39
  32   38   40
  33   39   41
  34   40   42
  35   43   45
  36   44   46
  37   45   47
  38   46   48
  39   47   49
  40   48   50
  41   49   51
  42   50   52
  43   51   53
  44   52   54
  45   53   55
  46   54   56
  47    1   15
  48    2   16
```

Figure 3.5.1. (continued).

49	15	29
50	16	30
51	29	43
52	30	44
53	3	17
54	4	18
55	17	31
56	18	32
57	31	45
58	32	46
59	5	19
60	6	20
61	19	33
62	20	34
63	33	47
64	34	48
65	7	21
66	8	22
67	21	35
68	22	36
69	35	49
70	36	50
71	9	23
72	10	24
73	23	37
74	24	38
75	37	51
76	38	52
77	11	25
78	12	26
79	25	39
80	26	40
81	39	53
82	40	54
83	27	41
84	28	42
85	41	55
86	42	56
87	1	2
88	3	4
89	5	6
90	7	8
91	9	10
92	11	12
93	15	16
94	17	18
95	19	20
96	21	22
97	23	24
98	25	26
99	27	28
100	29	30
101	31	32
102	33	34
103	35	36
104	37	38
105	39	40
106	41	42
107	43	44
108	45	46
109	47	48
110	49	50
111	51	52
112	53	54

Figure 3.5.1. (continued).

```
 113  56  56
ENDO
DISP       1    56 0.
   1          0.          0.          0.
   2          0.          0.          0.
   3          0.          0.          0.
   4          0.          0.          0.
   5          0.          0.          0.
   6          0.          0.          0.
   7          0.          0.          0.
   8          0.          0.          0.
   9          0.          0.          0.
  10          0.          0.          0.
  11          0.          0.          0.
  12          0.          0.          0.
  13          0.          0.          0.
  14          0.          0.          0.
  15          0.          0.          0.
  16          0.          0.          0.
  17           .106E-02    .160E-02    .422E-02
  18          -.106E-02   -.165E-02    .402E-02
  19           .148E-02    .216E-02    .673E-02
  20          -.143E-02   -.223E-02    .662E-02
  21           .138E-02    .240E-02    .762E-02
  22          -.138E-02   -.252E-02    .750E-02
  23           .875E-03    .208E-02    .602E-02
  24          -.908E-03   -.228E-02    .562E-02
  25          0.          0.          0.
  26          0.          0.          0.
  27          0.          0.          0.
  28          0.          0.          0.
  29           .330E-02    .506E-02    .751E-01
  30          -.261E-02   -.506E-02    .771E-01
  31           .325E-02    .552E-02    .869E-01
  32          -.259E-02   -.568E-02    .883E-01
  33           .300E-02    .640E-02    .970E-01
  34          -.254E-02   -.667E-02    .981E-01
  35           .325E-02    .746E-02    .106E+00
  36          -.257E-02   -.784E-02    .107E+00
  37           .340E-02    .861E-02    .113E+00
  38          -.280E-02   -.920E-02    .114E+00
  39           .360E-02    .930E-02    .120E+00
  40          -.284E-02   -.101E-01    .120E+00
  41           .282E-02    .104E-01    .152E+00
  42          -.197E-02   -.123E-01    .153E+00
  43           .701E-02    .570E-02    .310E+00
  44          -.498E-02   -.611E-02    .311E+00
  45           .832E-02    .718E-02    .332E+00
  46          -.618E-02   -.747E-02    .333E+00
  47           .983E-02    .864E-02    .358E+00
  48          -.770E-02   -.906E-02    .359E+00
  49           .114E-01    .108E-01    .387E+00
  50          -.938E-02   -.110E-01    .388E+00
  51           .129E-01    .128E-01    .419E+00
  52          -.109E-01   -.135E-01    .420E+00
  53           .138E-01    .144E-01    .448E+00
  54          -.117E-01   -.157E-01    .448E+00
  55           .123E-01    .152E-01    .581E+00
  56          -.107E-01   -.181E-01    .581E+00
ELSS       2      1 0.
ETYP       3      2      4    77
ELEM       1      4      4
   .388E-04   .114E-04 0.          0.          0.          .602E-04   .398E+03   .233E+03 0.          0.          0.          .232E+03   .530E+03
   .182E-03   .113E-04 0.          0.          0.          .206E-03   .138E+04   .526E+03 0.          0.          0.          .787E+03   .182E+04
```

Figure 3.5.1. (continued).

.334E-04	.432E-04	0.	0.	0.	.808E-04	.509E+03	.585E+03	0.	0.	0.	.311E+03	.771E+03
.124E-03	.430E-04	0.	0.	0.	.228E-03	.150E+04	.882E+03	0.	0.	0.	.877E+03	.201E+04
ELEM 2	4	4										
-.336E-04	-.117E-04	0.	0.	0.	-.620E-04	-.407E+03	-.239E+03	0.	0.	0.	-.230E+03	.544E+03
-.125E-03	-.117E-04	0.	0.	0.	-.211E-03	-.141E+04	-.539E+03	0.	0.	0.	-.811E+03	.187E+04
-.342E-04	-.446E-04	0.	0.	0.	-.831E-04	-.622E+03	-.602E+03	0.	0.	0.	-.319E+03	.782E+03
-.127E-03	-.443E-04	0.	0.	0.	-.236E-03	-.154E+04	-.906E+03	0.	0.	0.	-.902E+03	.206E+04
ELEM 3	4	4										
.117E-04	.597E-04	0.	0.	0.	.566E-04	.325E+03	.695E+03	0.	0.	0.	.218E+03	.710E+03
.434E-04	.596E-04	0.	0.	0.	.111E-03	.674E+03	.798E+03	0.	0.	0.	.427E+03	.106E+04
.119E-04	.728E-04	0.	0.	0.	.643E-04	.369E+03	.833E+03	0.	0.	0.	.247E+03	.840E+03
.443E-04	.721E-04	0.	0.	0.	.120E-03	.724E+03	.938E+03	0.	0.	0.	.401E+03	.117E+04
ELEM 4	4	4										
-.114E-04	-.615E-04	0.	0.	0.	-.583E-04	-.328E+03	-.714E+03	0.	0.	0.	-.224E+03	.731E+03
-.428E-04	-.614E-04	0.	0.	0.	-.115E-03	-.670E+03	-.816E+03	0.	0.	0.	-.443E+03	.108E+04
-.110E-04	-.746E-04	0.	0.	0.	-.658E-04	-.374E+03	-.858E+03	0.	0.	0.	-.253E+03	.865E+03
-.434E-04	-.745E-04	0.	0.	0.	-.124E-03	-.722E+03	-.962E+03	0.	0.	0.	-.476E+03	.120E+04
ELEM 5	4	4										
-.897E-06	.793E-04	0.	0.	0.	.567E-04	.252E+03	.869E+03	0.	0.	0.	.218E+03	.862E+03
-.336E-05	.793E-04	0.	0.	0.	.846E-04	.225E+03	.860E+03	0.	0.	0.	.325E+03	.956E+03
-.915E-06	.860E-04	0.	0.	0.	.563E-04	.274E+03	.942E+03	0.	0.	0.	.217E+03	.920E+03
-.341E-05	.860E-04	0.	0.	0.	.848E-04	.246E+03	.933E+03	0.	0.	0.	.326E+03	.101E+04
ELEM 6	4	4										
.383E-06	-.824E-04	0.	0.	0.	-.592E-04	-.267E+03	-.904E+03	0.	0.	0.	-.228E+03	.896E+03
.143E-05	-.823E-04	0.	0.	0.	-.923E-04	-.256E+03	-.900E+03	0.	0.	0.	-.355E+03	.101E+04
.381E-06	-.903E-04	0.	0.	0.	-.592E-04	-.293E+03	-.991E+03	0.	0.	0.	-.228E+03	.966E+03
.140E-05	-.902E-04	0.	0.	0.	-.930E-04	-.281E+03	-.987E+03	0.	0.	0.	-.358E+03	.108E+04
ELEM 7	4	4										
-.134E-04	.868E-04	0.	0.	0.	.351E-04	.139E+03	.910E+03	0.	0.	0.	.135E+03	.881E+03
-.501E-04	.868E-04	0.	0.	0.	.153E-04	-.264E+03	.789E+03	0.	0.	0.	.588E+02	.966E+03
-.137E-04	.818E-04	0.	0.	0.	.258E-04	.119E+03	.854E+03	0.	0.	0.	.992E+02	.819E+03
-.518E-04	.818E-04	0.	0.	0.	.547E-05	-.292E+03	.731E+03	0.	0.	0.	.210E+02	.913E+03
ELEM 8	4	4										
.130E-04	-.900E-04	0.	0.	0.	-.380E-04	-.160E+03	-.968E+03	0.	0.	0.	-.146E+03	.934E+03
.488E-04	-.898E-04	0.	0.	0.	-.227E-04	.233E+03	-.850E+03	0.	0.	0.	-.874E+02	.999E+03
.133E-04	-.881E-04	0.	0.	0.	-.289E-04	-.144E+03	-.925E+03	0.	0.	0.	-.111E+03	.883E+03
.498E-04	-.880E-04	0.	0.	0.	-.133E-04	.257E+03	-.804E+03	0.	0.	0.	-.512E+02	.963E+03
ELEM 9	4	4										
-.331E-04	.636E-04	0.	0.	0.	-.502E-04	-.154E+03	.589E+03	0.	0.	0.	-.193E+03	.757E+03
-.184E-03	.630E-04	0.	0.	0.	-.263E-03	-.115E+04	.292E+03	0.	0.	0.	-.101E+04	.219E+04
-.337E-04	.173E-04	0.	0.	0.	-.713E-04	-.313E+03	.794E+02	0.	0.	0.	-.274E+03	.596E+03
-.188E-03	.174E-04	0.	0.	0.	-.288E-03	-.133E+04	-.225E+03	0.	0.	0.	-.111E+04	.228E+04
ELEM 10	4	4										
.343E-04	-.680E-04	0.	0.	0.	.557E-04	.149E+03	-.644E+03	0.	0.	0.	.214E+03	.819E+03
.128E-03	-.692E-04	0.	0.	0.	.286E-03	.118E+04	-.337E+03	0.	0.	0.	.110E+04	.235E+04
.348E-04	-.188E-04	0.	0.	0.	.777E-04	.322E+03	-.916E+02	0.	0.	0.	.299E+03	.640E+03
.131E-03	-.189E-04	0.	0.	0.	.312E-03	.138E+04	.224E+03	0.	0.	0.	.120E+04	.244E+04
ELEM 11	4	4										
.833E-04	.106E-03	0.	0.	0.	.266E-03	.126E+04	.143E+04	0.	0.	0.	.986E+03	.218E+04
-.196E-04	.137E-03	0.	0.	0.	.108E-03	.236E+03	.144E+04	0.	0.	0.	.763E+03	.188E+04
.837E-04	.923E-04	0.	0.	0.	.242E-03	.122E+04	.129E+04	0.	0.	0.	.938E+03	.205E+04
-.176E-04	.121E-03	0.	0.	0.	.183E-03	.206E+03	.127E+04	0.	0.	0.	.708E+03	.170E+04
ELEM 12	4	4										
-.861E-04	-.101E-03	0.	0.	0.	-.247E-03	-.128E+04	-.140E+04	0.	0.	0.	-.950E+03	.212E+04
.158E-04	-.128E-03	0.	0.	0.	-.200E-03	-.256E+03	-.136E+04	0.	0.	0.	-.770E+03	.183E+04
-.865E-04	-.898E-04	0.	0.	0.	-.233E-03	-.125E+04	-.127E+04	0.	0.	0.	-.896E+03	.200E+04
.130E-04	-.115E-03	0.	0.	0.	-.185E-03	-.231E+03	-.122E+04	0.	0.	0.	-.710E+03	.166E+04
ELEM 13	4	4										
.182E-04	.129E-03	0.	0.	0.	.115E-03	.627E+03	.148E+04	0.	0.	0.	.442E+03	.150E+04
-.481E-04	.114E-03	0.	0.	0.	.186E-03	-.887E+02	.111E+04	0.	0.	0.	.716E+03	.170E+04
.184E-04	.137E-03	0.	0.	0.	.106E-03	.654E+03	.156E+04	0.	0.	0.	.408E+03	.153E+04
-.410E-04	.122E-03	0.	0.	0.	.175E-03	-.471E+02	.121E+04	0.	0.	0.	.674E+03	.170E+04
ELEM 14	4	4										
-.108E-04	-.129E-03	0.	0.	0.	-.103E-03	-.610E+03	-.147E+04	0.	0.	0.	-.397E+03	.145E+04

Figure 3.5.1. (continued).

```
ELEM     77    4    4
  .126E-03  .193E-03 0.  0.  0.  .262E-02 0.  0.  0.  0.  0.  .262E+05  .454E+06
 -.126E-03  .193E-03 0.  0.  0.  .260E-02 0.  0.  0.  0.  0.  .260E+05  .451E+05
  .120E-03 -.698E-04 0.  0.  0. -.821E-03 0.  0.  0.  0.  0. -.821E+04  .142E+05
 -.149E-03 -.698E-04 0.  0.  0. -.840E-03 0.  0.  0.  0.  0. -.840E+04  .140E+05
ETYP      4    1    0  113
ELEM      1    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM      2    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM      3    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM      4    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM      5    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM      6    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM      7    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM      8    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM      9    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM     10    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM     11    2    1
  .114E-03 0.  0.  0.  0.  0.  .114E+04 0.  0.  0.  0.  0.  .114E+04
ELEM     12    2    1
 -.116E-03 0.  0.  0.  0.  0. -.116E+04 0.  0.  0.  0.  0.  .116E+04
ELEM     13    2    1
  .362E-04 0.  0.  0.  0.  0.  .362E+03 0.  0.  0.  0.  0.  .362E+03
ELEM     14    2    1
 -.344E-04 0.  0.  0.  0.  0. -.344E+03 0.  0.  0.  0.  0.  .344E+03
ELEM     15    2    1
 -.162E-04 0.  0.  0.  0.  0. -.162E+03 0.  0.  0.  0.  0.  .162E+03
ELEM     16    2    1
  .151E-04 0.  0.  0.  0.  0.  .151E+03 0.  0.  0.  0.  0.  .151E+03
ELEM     17    2    1
 -.615E-04 0.  0.  0.  0.  0. -.615E+03 0.  0.  0.  0.  0.  .615E+03
ELEM     18    2    1
  .611E-04 0.  0.  0.  0.  0.  .611E+03 0.  0.  0.  0.  0.  .611E+03
ELEM     19    2    1
 -.104E-03 0.  0.  0.  0.  0. -.104E+04 0.  0.  0.  0.  0.  .104E+04
ELEM     20    2    1
  .105E-03 0.  0.  0.  0.  0.  .105E+04 0.  0.  0.  0.  0.  .105E+04
ELEM     21    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM     22    2    1
 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
ELEM     23    2    1
 -.615E-04 0.  0.  0.  0.  0. -.615E+03 0.  0.  0.  0.  0.  .615E+03
ELEM     24    2    1
  .548E-04 0.  0.  0.  0.  0.  .548E+03 0.  0.  0.  0.  0.  .548E+03
ELEM     25    2    1
 -.549E-04 0.  0.  0.  0.  0. -.549E+03 0.  0.  0.  0.  0.  .549E+03
ELEM     26    2    1
  .535E-04 0.  0.  0.  0.  0.  .535E+03 0.  0.  0.  0.  0.  .535E+03
ELEM     27    2    1
 -.282E-04 0.  0.  0.  0.  0. -.282E+03 0.  0.  0.  0.  0.  .282E+03
ELEM     28    2    1
  .306E-04 0.  0.  0.  0.  0.  .306E+03 0.  0.  0.  0.  0.  .306E+03
ELEM     29    2    1
```

Figure 3.5.1. (continued).

```
ELEM   110   2    1
  .338E-03 0.       0.        0.        0.        0.        .338E+04 0.       0.        0.        0.        0.        .338E+04
ELEM   111   2    1
  .244E-03 0.       0.        0.        0.        0.        .244E+04 0.       0.        0.        0.        0.        .244E+04
ELEM   112   2    1
  .377E-04 0.       0.        0.        0.        0.        .377E+03 0.       0.        0.        0.        0.        .377E+03
ELEM   113   2    1
 -.183E-03 0.       0.        0.        0.        0.       -.183E+04 0.       0.        0.        0.        0.        .183E+04
..
```

Figure 3.5.1. (concluded).

SECTION 4

POSTPROCESSING PROGRAMS PLOTBOB AND CONTOUR

4.1 INTRODUCTION

Finite element analysis tends to utilize a large portion of computer resources to accomplish the task of determining whether or not a structure is safe and reliable. The output from such a program can be voluminous and therefore very difficult to interpret or comprehend. Postprocessing or post-analysis manipulation of the output data from MAGNA is the primary function of PLOTBOB and CONTOUR plotting programs. The programs address themselves to the requirements of efficiently and understandably presenting the MAGNA analysis results to the user to provide a more comprehensible understanding of what the results actually indicate about the model in question and to directly tie the model developed with the results achieved.

PLOTBOB provides the user with the capability to plot a structure prior to analysis utilizing the MAGNA input file (load deck created on TAPE 11 by WINGEN) as well as the ability to selectively plot deformed structures utilizing an -MPOST file. The preprocessor output file may be input to PLOTBOB without any changes after it is created by WINGEN. The user may wish to view the model (especially if shell elements were selected for upper and lower skins) with the more sophisticated capabilities of PLOTBOB, as compared with the plotting capabilities of WINGEN, to better ensure the model was properly defined prior to MAGNA analysis. The user should be aware that no deformed plotting may occur with a MAGNA input file because there is no data indicating what a deformed model would be until after the analysis run. PLOTBOB can also be utilized for post-analysis plotting of the model. This is limited to plotting deformed structures (contour plotting is limited to CONTOUR) but all the capabilities for selective viewing are available for use with the deformed structure plots.

CONTOUR is a second general-purpose plotting program for use with MAGNA analysis output data. Unlike PLOTBOB it cannot plot any MAGNA input files but it has the capability to plot deformed geometry structures and superimpose on structures contour lines representing different stresses, strains or displacements. This can be very informative in assisting the user with determining where and when structural failure might occur. With capability for significant labeling of the model, contour lines and the entire plot, CONTOUR provides the user with excellent documentation of output results. Figures 4.1.1 and 4.1.2 illustrate sample plots from both PLOTBOB and CONTOUR to allow the user a comparison of their capabilities. The remainder of this chapter deals with how to use these two programs. Reference 4 provides some additional information on the postprocessing programs. The program names in Reference 4 are different, however, PLOTBOB has been renamed to GPLOT and CONTOUR has been renamed to CPLOT.

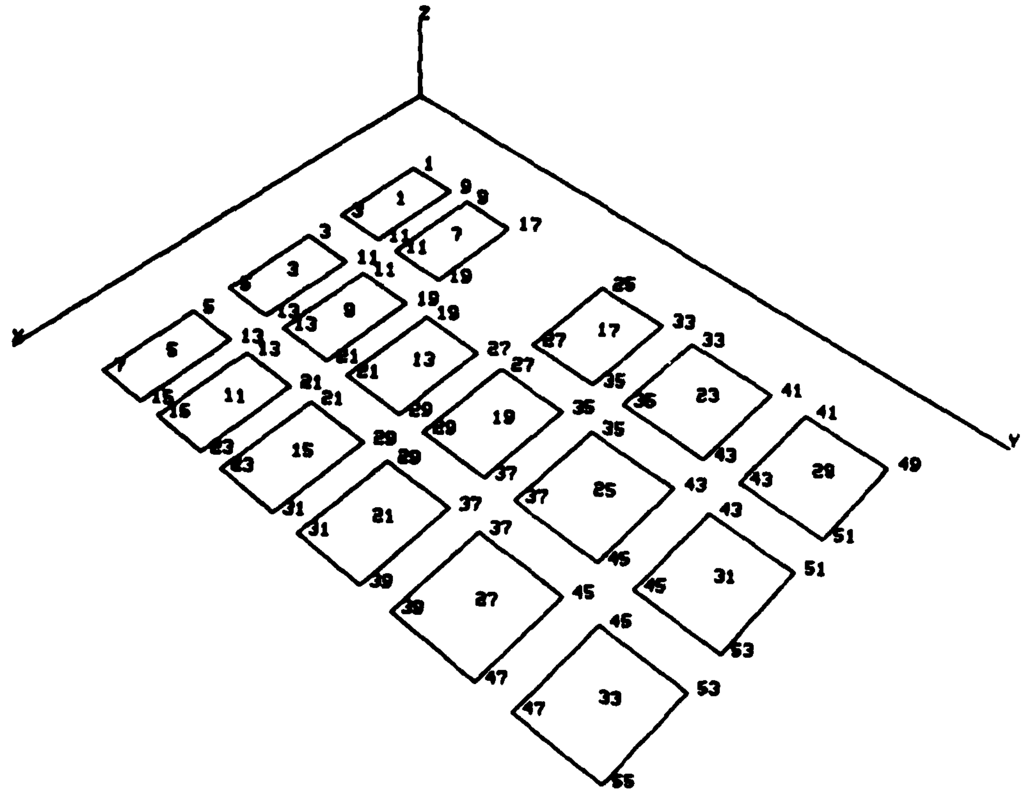


Figure 4.1.1. Typical plot from PLOTBOB plotting program. This illustrates the lower wing skin of a Replica Wing Test Specimen with the elements shrunken and damage to the skin element in chord bay 1 span bay 3.

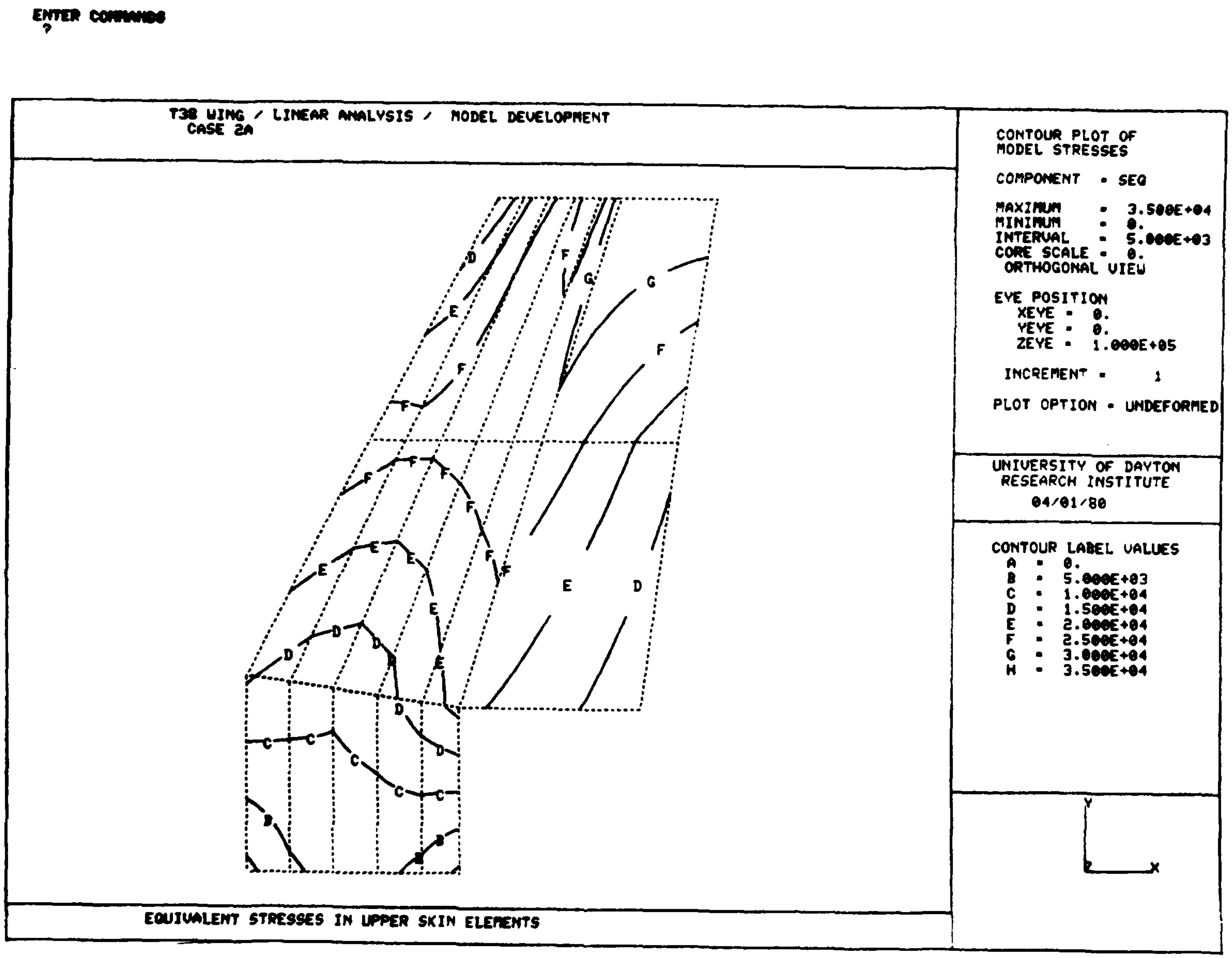


Figure 4.1.2. Typical plot from CONTOUR plotting program. This illustrates the equivalent stresses present in the upper wing skin of a T-38 aircraft wing under certain load conditions.

4.2 PLOTBOB - INTRODUCTION

PLOTBOB is a versatile, interactive finite element model (FEM) plotting program. The program can plot a model both before (preprocessor output file TAPE11) and after (MAGNA generated WINGMPOST file) MAGNA program execution. Any portion of the model can be viewed by specifying individual elements for plotting; zooming on the structure utilizing either of two methods available; or clipping away part of the structure to view inside. An exploded view option is also available. The model can be rotated, translated and reflected about axes as necessary for optional viewing. It can be viewed to scale with an axonometric or three point perspective projection. The user can label the elements and nodes by element, type, surface location and edge location.

4.2.1 Procedure for Executing

PLOTBOB may be executed using the methods outlined below for the CDC6600 computer:

```
LOGIN,...
ATTACH,F,PLOTTINGPROCEDURES,ID=XXXX,SN=XXXX
ATTACH,TAPE5,pfn  (desired data file)
BEGIN,PLTBOB,F    (,H for HP 7221 plotter)
                  (blank for Tektronix terminal)
```

PLOTTING PROCEDURES is a job control procedure which performs the process of attaching and defining the libraries and attaching and executing the program PLOTBOB. The parameters on the BEGIN command above specify whether the user is utilizing a Tektronix graphics terminal or a Hewlett-Packard 7221 bed plotter. No additional information is required if using a Tektronix terminal only: BEGIN,PLTBOB,F. An additional character should be appended to the command if one is using the HP plotter as follows: BEGIN,PLTBOB,F,H.

PLOTBOB will always look for a local file with the name 'TAPE5' which contains the input data defining the fem model to be displayed. This data may be either a preprocessor output file (TAPE11) containing all the data necessary for a FEM analysis (type 1) or it may be a FEM analysis output file (-MPOST file) containing all the analysis data along with the model definition data (type 2). The program will ask the user which file type he is using: 1 or 2. The preprocessor output file is detailed in section 3.2. The FEM analysis output file is explained in Section 3.3.

4.2.2 Command Structure

Once PLOTBOB has been initiated the program will prompt the user with several questions:

```
ENTER THE CHARACTERS PER SECOND..........:
TYPE OF PLOTTER (T,H)....................:
ENTER DATA FILE TYPES:
    1 = PREPROCESSOR DATA FILE
    2 = MPOST FILE
ENTER DATA FILE TYPE (1,2)...............:
```

These questions control program functioning. The characters transmitted per second (cps) are a function of the baud rate: on a CDC 1/10 *baud rate yields the cps. The type of plotter can be either a Tektronix 4010 series (T), a Tektronix 4010 series emulator (T), a Hewlett-Packard 7221 (H) or any terminal or plotter operating under Tektronix PLOT10 Terminal Control system (TCS) routines (T) or Hewlett-Packard HPPLOT21 graphics library routines (H). The PLOTBOB program will handle two types of data files as discussed above for TAPE5, a preprocessor output file or a MAGNA generated WINGMPOST.

Once satisfactory responses have been received by the program it will prompt the user with an asterisk (*). The user may then enter any valid command (for a list of commands type 'HELP') by typing the first four letters of the command and pressing the <CR> (carriage return). Any number of commands may be entered and reentered until the time limit of the program has expired, the user issues the 'STOP' command or there is an execution error. Section 4.2.3 discusses the commands available.

4.2.3 Command Summary

This section lists each command available to the PLOTBOB program user in alphabetical order with a brief description of each. Only the first four letters of each command are required. Ample illustrations have been provided to allow the user a more complete understanding of each command. Additional information may be provided in Section 4.3.4 for the CONTOUR program commands which perform similar functions. Figure 4.2.1 lists the commands covered in this section.

4.2.3.1 AXES

This command allows the user to plot a set of orthogonal axes labeled "x", "y", and "z". Each structure (finite element model) is defined using a 3-D coordinate system. The program accepts input for Cartesian, cylindrical, and spherical coordinates though it can, by program modification, accept other user coordinate systems. Those coordinates which are linear, rather than angular, in nature can be expressed in any units of length the user desires. In general, these units are the same as those used in taking measurements of the actual structure. All locating of points on the structure with the user coordinate system and unit of length is done from an arbitrary (0,0,0) point called the origin.

The axes extend from the origin in the positive x-, y-, and z-directions. The length of each axis is 10 percent greater than the maximum distance of the structure from the origin in the same direction. For example, if the maximum distance of the structure from the origin in the x-direction is 10 mm (i.e., the maximum x-coordinate is 10) then the length of the x-axis if 11 mm. This is true regardless

```
COMMAND          DESCRIPTION
*******          ***********
 AXES             AXES DRAW AND LABEL
 CLIP             CLIP PLANE POSITION
 CUBE             SET MINIMA AND MAXIMA
 DEFAULT          SET DEFAULT VALUES
 DEFORM           DEFORMED MODEL REPRESENTATION
 DRAW             DRAW MODEL
 ELEMENTS         PLOTS ALL OR SELECTED ELEMENTS
 EYE              EYE POSITION
 HELP             LIST ALL COMMANDS
 LABELS           LABELS ELEMENTS AND/OR NODES
 NEW              NEW STRUCTURE
 PROJECTION       PROJECTION TYPE
 REFLECT          REFLECT A PLANE
 ROTATE           ROTATE MODEL ABOUT AXES
 SCALE            SCALE PLOT
 SHRINK           SHRINK ELEMENTS
 STOP             END PROGRAM
 SUMMARY          LIST ALL PARAMETER VALUES
 TIME             PRINT CPU TIME SINCE START OF SESSION
 TRANSLATE        TRANSLATE MODEL FROM ORIGIN
 VERTICAL         VERTICAL AXIS
 ZOOM             ZOOM ON THE MODEL
*
```

Figure 4.2.1. PLOTBOB commands summary. This list may be obtained by issuing the 'HELP' command.

of whether or not the structure coincides with the origin. The x-axis length is based only on the maximum x-coordinate. No axes are plotted when the default value is specified.

4.2.3.2 CLIP (Figures 4.2.2 and 4.2.3)

CLIP gives the user an opportunity to clip off a portion of the structure to be plotted in order to look inside. The user specifies the location of the clip plane by entering a clip factor, which is defined as

$$CLPFAC = C/P$$

where C is the distance from the eye to the clip plane and P is the distance from the eye to the site position. The site position is the centroid of the structure. Any portion of the structure between the eye and the clip plane will not be mapped onto the virtual plane (see SCALE), and thus will not appear at the plotter. The default value for CLPFAC is 0.01.

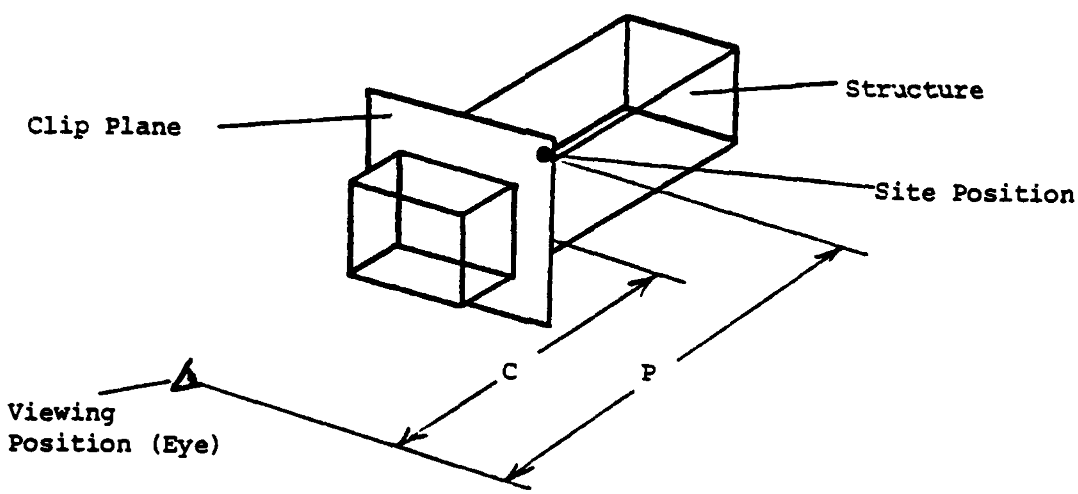


Figure 4.2.3. Illustration of CLIP command definitions

4.2.3.3 CUBE (Figure 4.2.4)

CUBE changes the viewing box size in order to give close-ups of particular parts of a structure.

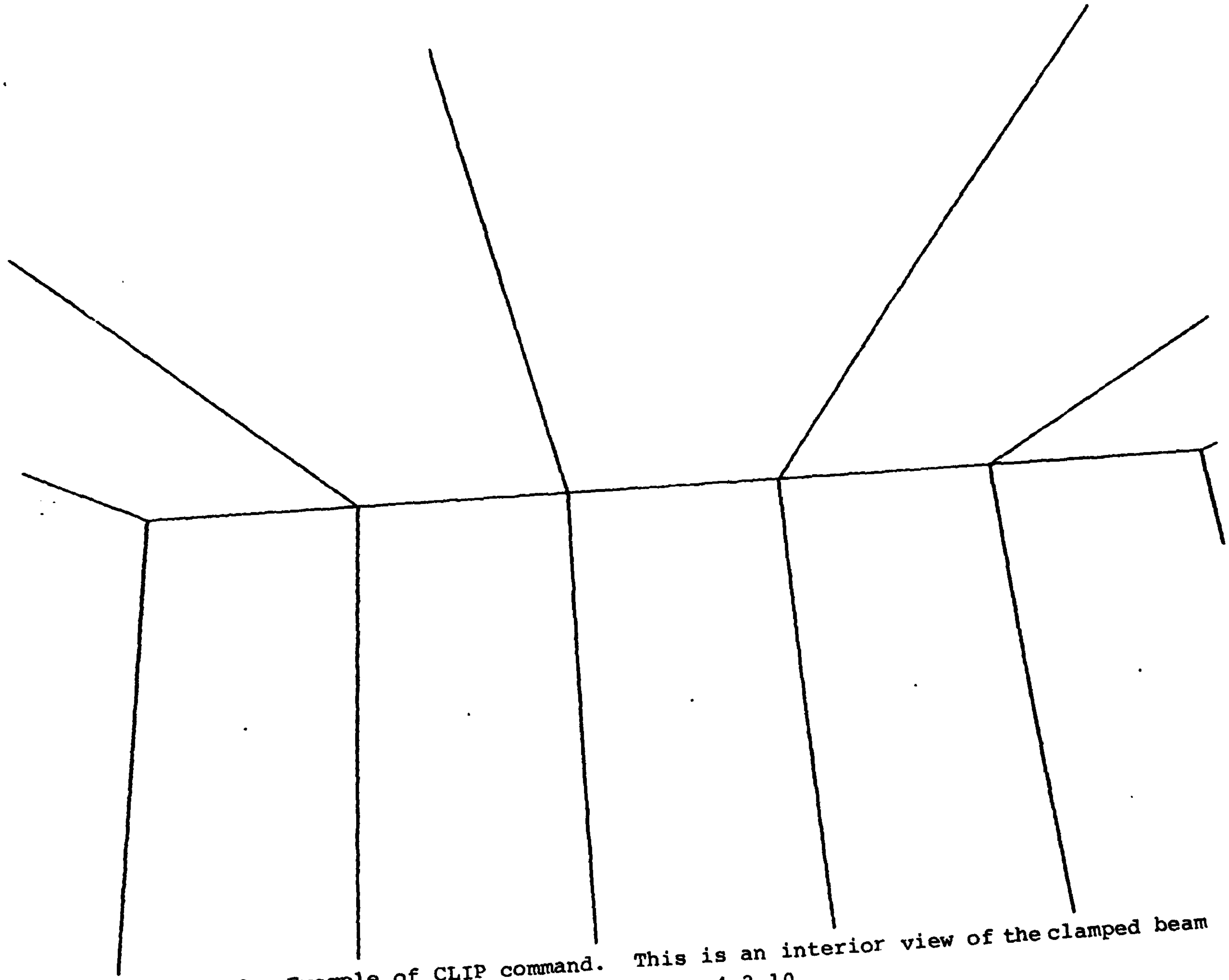


Figure 4.2.2. Example of CLIP command. This is an interior view of the clamped beam structure illustrated in Figure 4.2.10.

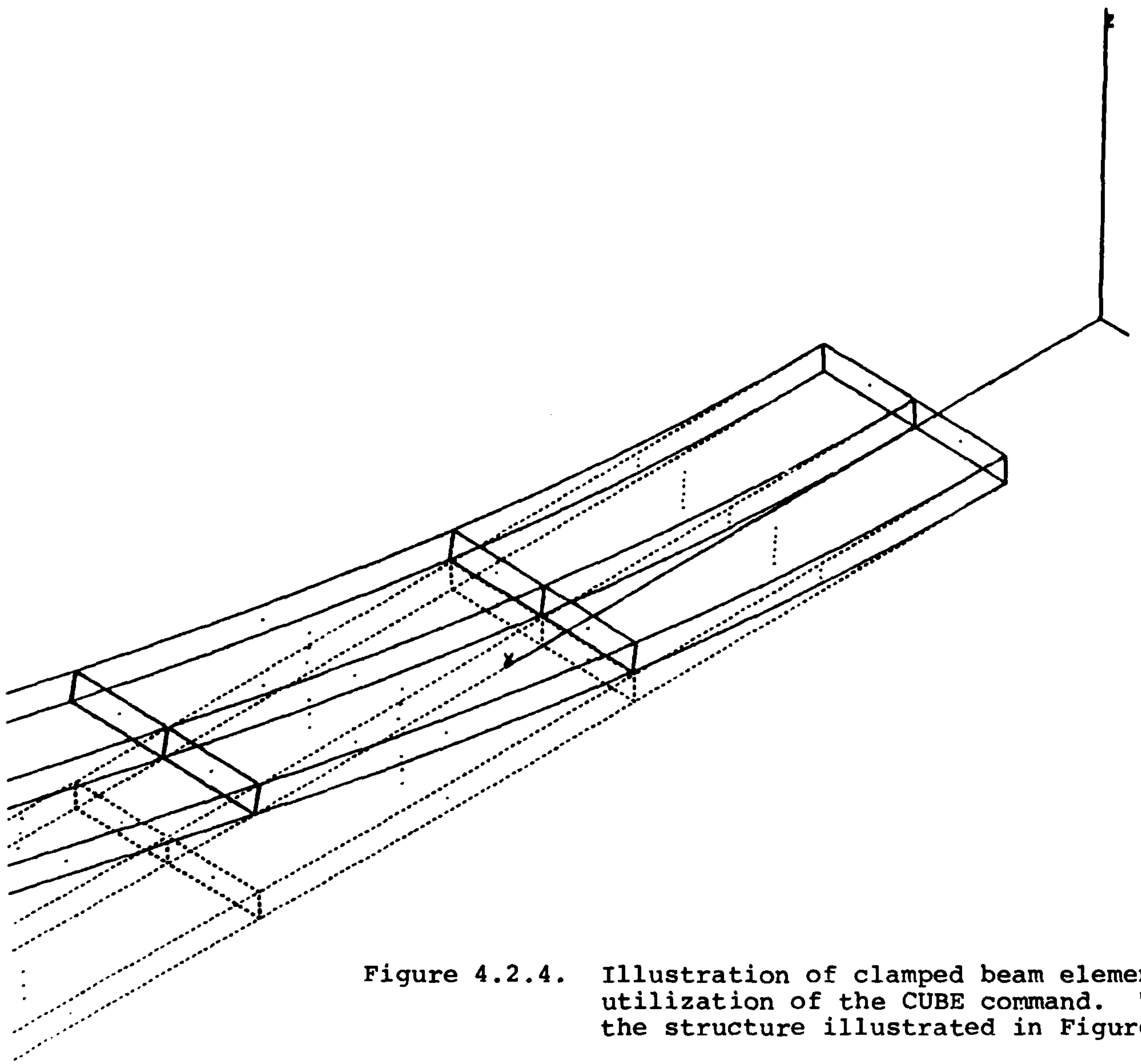


Figure 4.2.4. Illustration of clamped beam elements viewed after utilization of the CUBE command. This is a zoom on the structure illustrated in Figure 4.2.14.

For default, the vertices of the imaginary viewing box coincide with the maximum and minimum points of the structure in each direction. Using CUBE, the user can change these maximum and minimum values to contain only that portion of the structure he wishes to observe. Once these values are chosen, the user can then view this portion from any position he desires without having to re-enter the CUBE command each time to obtain a new virtual plane and image (which the user must do with the ZOOM command). To use this command effectively, the user should be familiar with the dimensions of the structure being plotted in order to select suitable maximum and minimum values for the new viewing box.

4.2.3.4 DEFAULT

DEFAULT sets the plotting parameters controlled by user commands to correspond with the default values given in the descriptions of each command.

4.2.3.5 DEFORM (Figure 4.2.5)

DEFORM provides the user with the capability of one of three plotting options: (1) undeformed structure plot; (2) deformed structure plor, or (3) both deformed and undeformed structure plots. The undeformed option gives a plot of the structure as it would appear prior to loading being applied. If the user is executing this program with file type 1 (input load deck data file) this is the only option available. A postprocessor file (-MPOST file) will contain information allowing for deformed structure plots.

A deformed structure plot represents only the deformed structure as a result of loads applied during analysis. Only -MPOST post analysis files may have deformed structure plots.

The last option available is for both deformed and undeformed structure plots. The undeformed structure is drawn with a dashed line and the deformed structure is drawn in solid lines, superimposed on the undeformed structure.

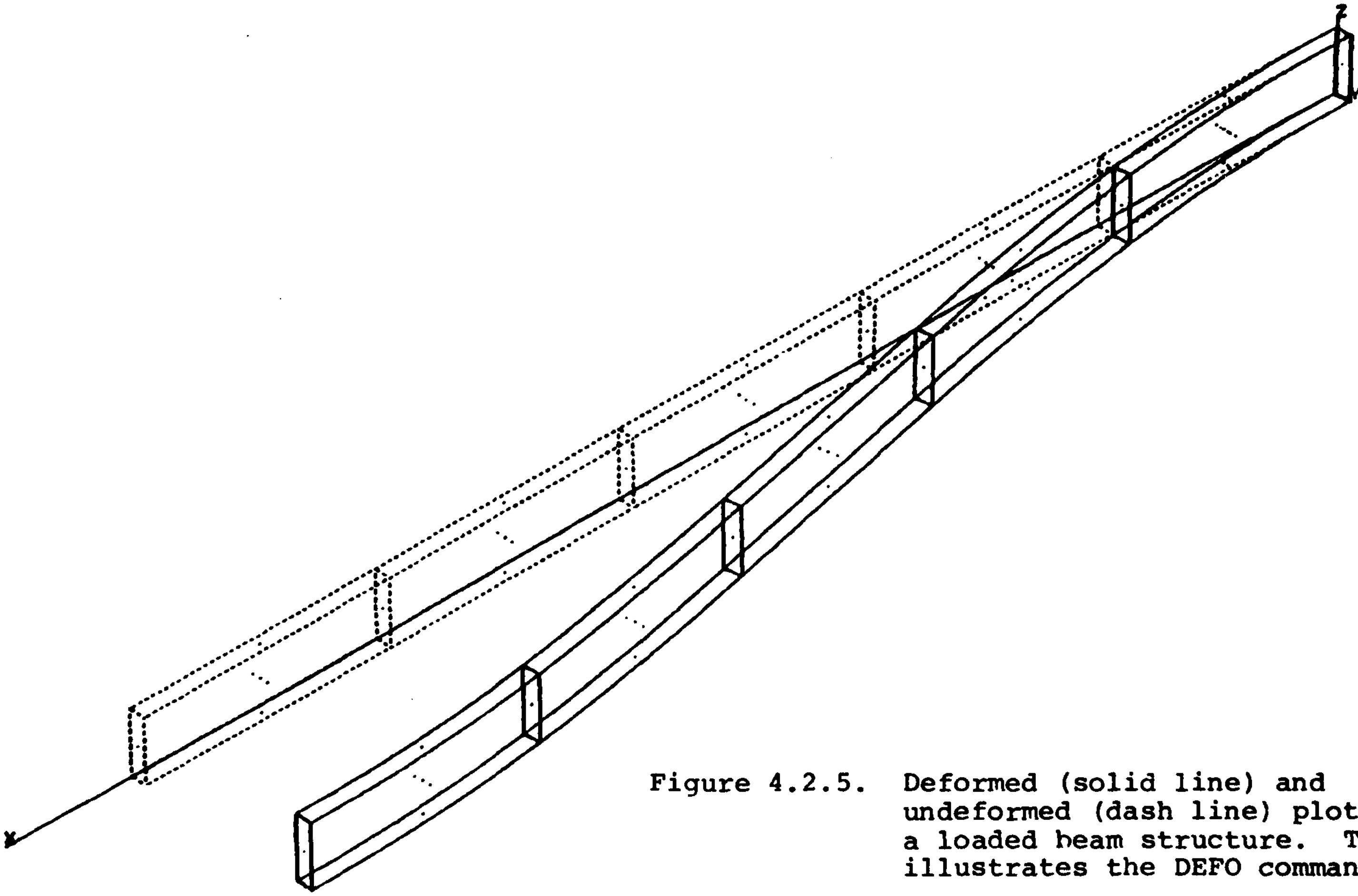


Figure 4.2.5. Deformed (solid line) and undeformed (dash line) plot of a loaded beam structure. This illustrates the DEFO command.

Once the plot option has been selected the program will display the maximum and minimum coordinate values for the undeformed case. If the user has selected a deformed structure plot the program will then request a file increment number. A file increment number corresponds to one of the load intervals requested during the analysis run. When the load deck was created (Section 2.9) the user input a load increment value and the number of steps or increments over which the load was to be applied. The increment requested here reflects which step of the loading process the user wishes to view; 1 is low (lightest load or only load in most linear analyses) and N is the highest load increment available on the file (generally 20 for nonlinear static analyses). Once the user selects a load increment the program will return the maximum and minimum displacements of the deformed structure. The user can compare this max/min value with the undeformed max/min value to determine an appropriate scale factor to multiply the deformed structure coordinates by in order to better resolve the two structures as well as to expand or exaggerate the model deformities. The program will request the scale factor as the last parameter for this command. The default for DEFORM is undeformed structure plot only.

4.2.3.6 DRAW

The DRAW command plots a structure according to the values stored in the plotting parameters.

4.2.3.7 ELEMENTS (Figure 4.2.6)

The user, employing the ELEMENTS command, can choose which elements he wishes to plot. After entering the number of different element types to be plotted, the program requests the first element type from which to select elements for plotting. The available element types are

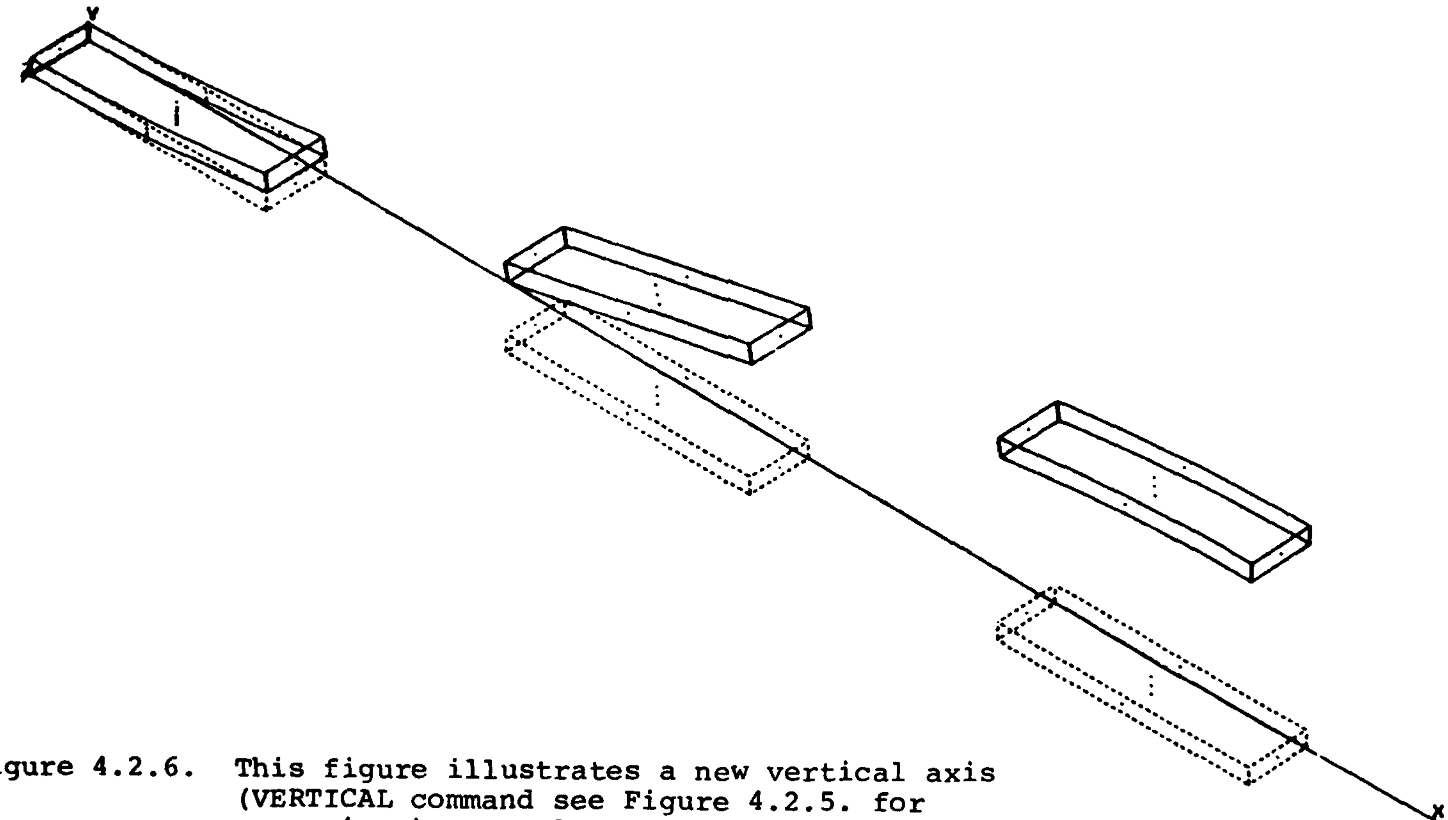


Figure 4.2.6. This figure illustrates a new vertical axis (VERTICAL command see Figure 4.2.5. for comparison) and selected elements plotting. The ELEMENTS command has been utilized to selectively plot 3 of the 5 elements of this structural model. This illustration is of a deformed and undeformed structure.

TYPE	DESCRIPTION
1	Variable number of nodes solid (up to 27 nodes)
2	Eight node brick
3*	Four node plate element
4*	Two node bar element
5*	Eight node shell element
6	Twenty node solid element
7	Variable number of nodes solid (up to 20 nodes)
8	Sixteen node solid element

*denotes element types used for wing modeling

Of course, not every structure will contain all of these, so the user must be familiar with the data he wishes to plot. After this step, the user enters the elements of his choice using one of three methods.

Method 1 - Select random elements by entering the number of elements to be plotted followed by the element numbers themselves.

Example - entering 4, 1, 8, 10, 23 would plot four elements, numbers 1, 8, 10, and 23.

Method 2 - Select a range of elements by entering the first and last element in the range, followed by an increment number.

Example - entering 1, 13, 3 would plot elements 1, 4, 7, 10, and 13.

Method 3 - Plot all of the elements for the present type. Elements are numbered consecutively through each element type. Thus, if a structure consists of 15 type 1 elements and five type 2 elements, the first set of elements would be numbered 1 through 15, and the second, 16 through 20. This procedure is then repeated for the next element type and so on, until all the elements the user desires to plot have been entered. The default is that all elements for all types present are plotted.

4.2.3.8 EYE (Figure 4.2.7)

A structure may be viewed from any position in space. This position is defined by a 3-D Cartesian coordinate measured relative to the structure origin (see AXIS).

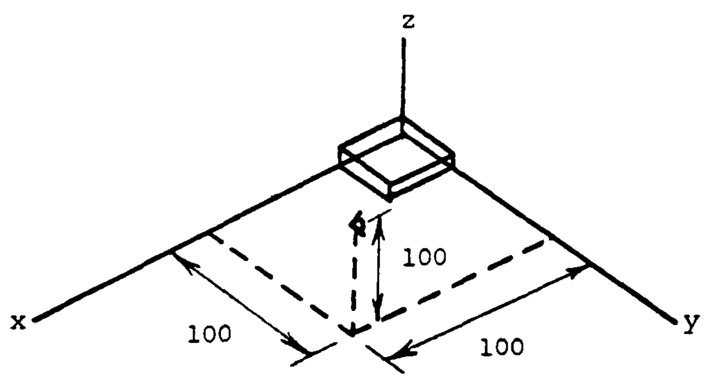


Figure 4.2.7. Default Viewing Position for EYE Command.

The default value is (100,100,100). EYE allows the user to move to a different viewing location. There is no restriction on this location; however, if it is located too close to or within the structure, portions of the resulting plot will be clipped, i.e., part of the structure's image will be cut off the screen. Subroutine CLIP contains a full explanation of the clipping process.

4.2.3.9 HELP (Figure 4.2.8)

HELP gives a list of all available commands with a brief description of each.

```
COMMAND        DESCRIPTION
*******        ***********
 AXES           AXES DRAW AND LABEL
 CLIP           CLIP PLANE POSITION
 CUBE           SET MINIMA AND MAXIMA
 DEFAULT        SET DEFAULT VALUES
 DEFORM         DEFORMED MODEL REPRESENTATION
 DRAW           DRAW MODEL
 ELEMENTS       PLOTS ALL OR SELECTED ELEMENTS
 EYE            EYE POSITION
 HELP           LIST ALL COMMANDS
 LABELS         LABELS ELEMENTS AND/OR NODES
 NEW            NEW STRUCTURE
 PROJECTION     PROJECTION TYPE
 REFLECT        REFLECT A PLANE
 ROTATE         ROTATE MODEL ABOUT AXES
 SCALE          SCALE PLOT
 SHRINK         SHRINK ELEMENTS
 STOP           END PROGRAM
 SUMMARY        LIST ALL PARAMETER VALUES
 TIME           PRINT CPU TIME SINCE START OF SESSION
 TRANSLATE      TRANSLATE MODEL FROM ORIGIN
 VERTICAL       VERTICAL AXIS
 ZOOM           ZOOM ON THE MODEL
*
```

Figure 4.2.8. Illustration of command listing generated by HELP command.

4.2.3.10 LABEL (Figures 4.2.9 and 4.2.10)

LABEL permits the user to label the elements and nodes of a structure. If the user responds affirmatively to the question concerning the labeling of the elements, all elements which are plotted will be labeled. Labeling for each element occurs at its centroid.

To label the nodes, the user first specifies the number of element types which will receive node labeling. He then enters an element type followed by a number corresponding to the surface he wishes to label. The choices available are 0 through 6 inclusive, where 0 denotes the labeling of all the nodes. Choices 1 through 6 for solid and plane elements are shown in Figures 4.2.9 and 4.2.10.

Note that the surface and edges are defined by the local node numbers encompassing them, rather than by their orientation in space. Thus, for example, surface 5 is always the surface containing local nodes 1, 2, 5, and 6. The process is then repeated for each element type. Default is no labeling of elements and nodes.

4.2.3.11 NEW

With this command the user can request that a different structure be plotted. There must be more than one structure present on the data file (TAPE5). A different structure is specified using the number corresponding to its location on TAPE5, i.e., to specify the third structure, the user enters a 3. Each set of data has a header card with the string "COOR" in the first four columns. This line immediately precedes all the information concerning the nodal coordinates and element connectivities for that structure. Generally, multiple linear analyses may be executed on one structure generating one structure with several increments, similar to a nonlinear analysis with several load steps. Several such output files may be placed on a single file following the analyses which would result in multiple structures on the file.

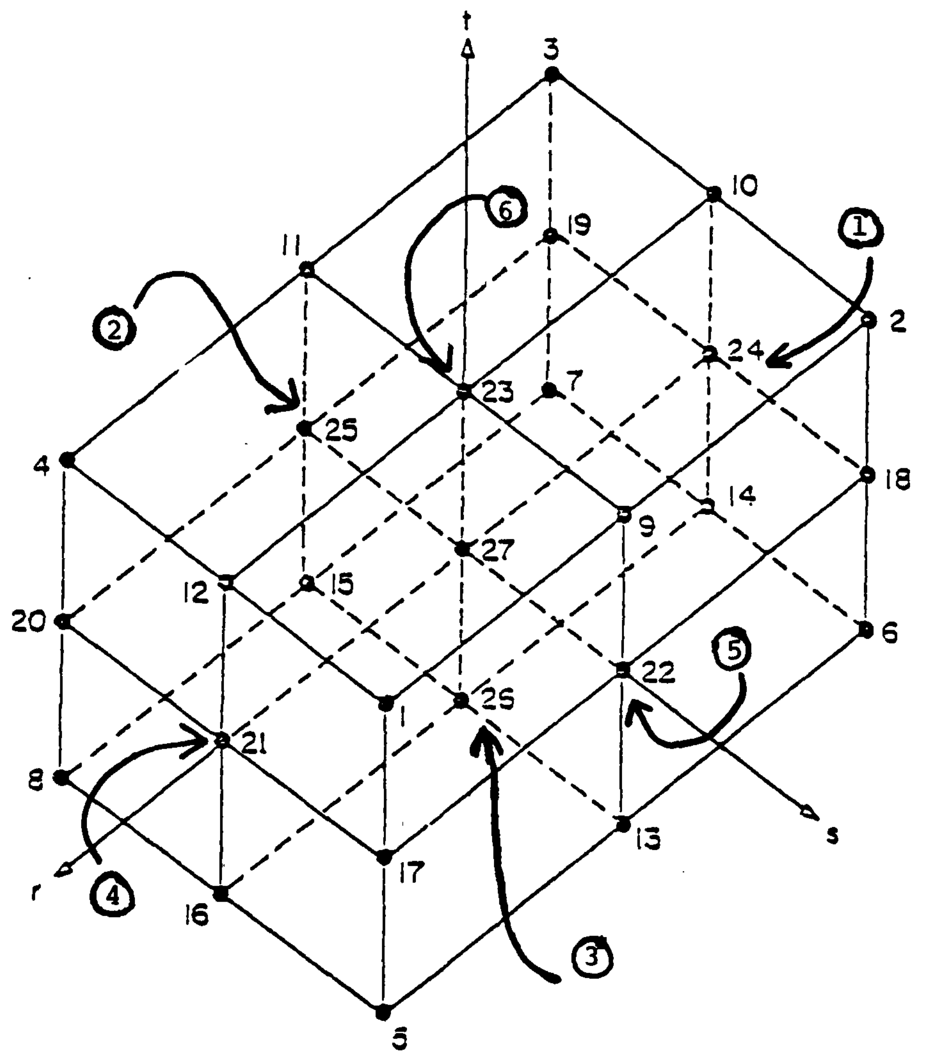


Figure 4.2.9. The surfaces 1-6 are illustrated here for element type 1 - a 27 node solid element. All other element types are degenerate to element type 1.

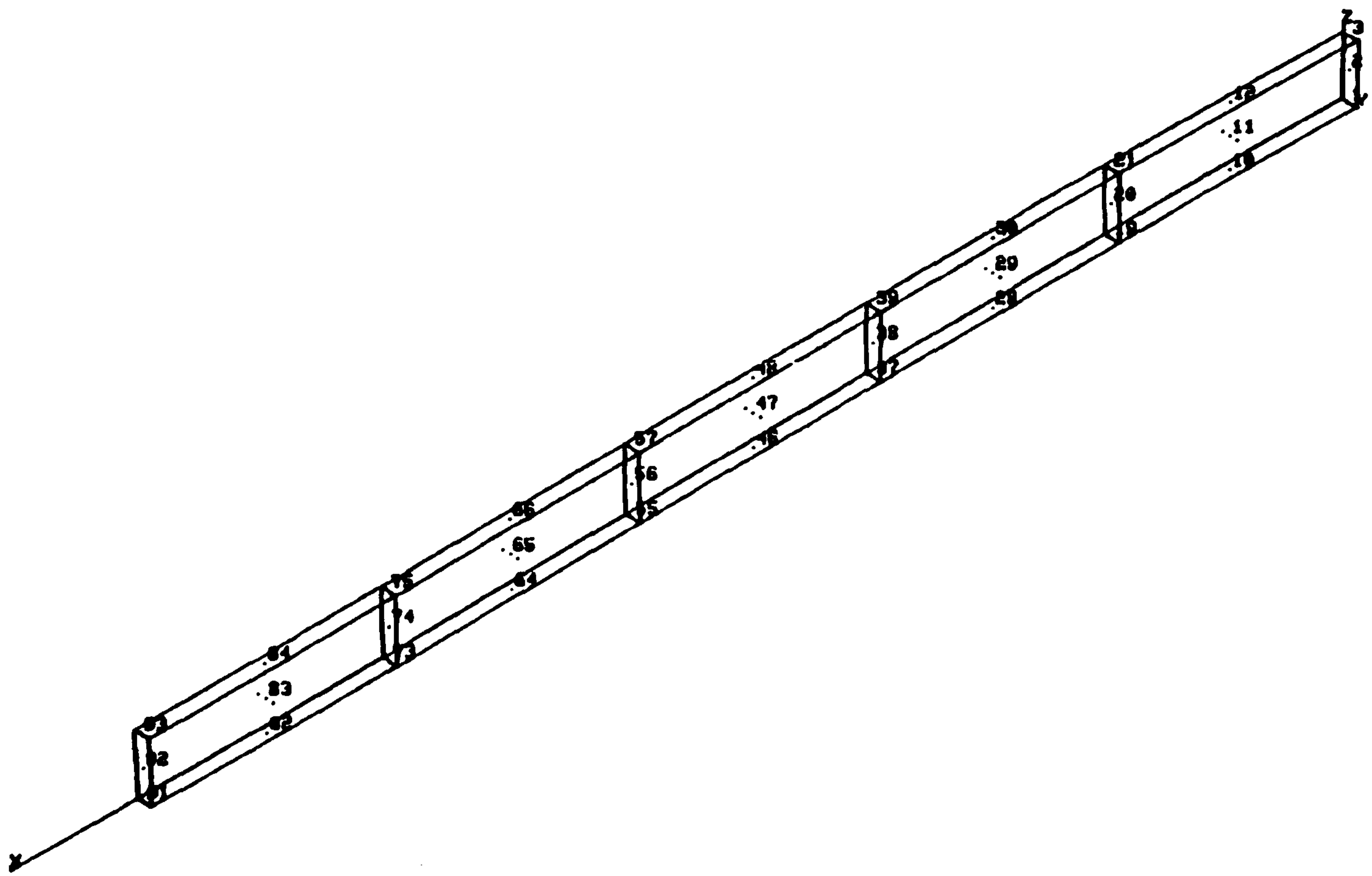


Figure 4.2.10. Example of clamped beam structure with nodes labeled on surface 5.

4.2.3.12 PROJECTION (Figures 4.2.11, 4.2.12 and 4.2.13)

PROJECTION gives the user his choice of pictorial projection. The two choices available are orthogonal (axonometric), which is requested by the letter O, and perspective (three-point perspective), which is requested by the letter P. The orthogonal projection is formed by using projection lines which are perpendicular to the virtual plane described in SCALE. The result is an image in which lines

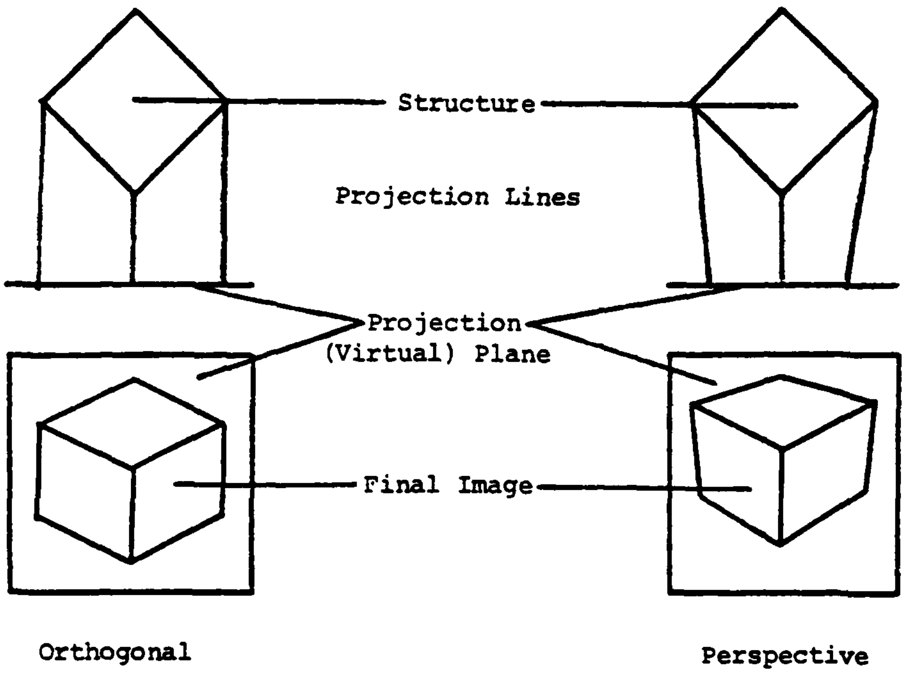
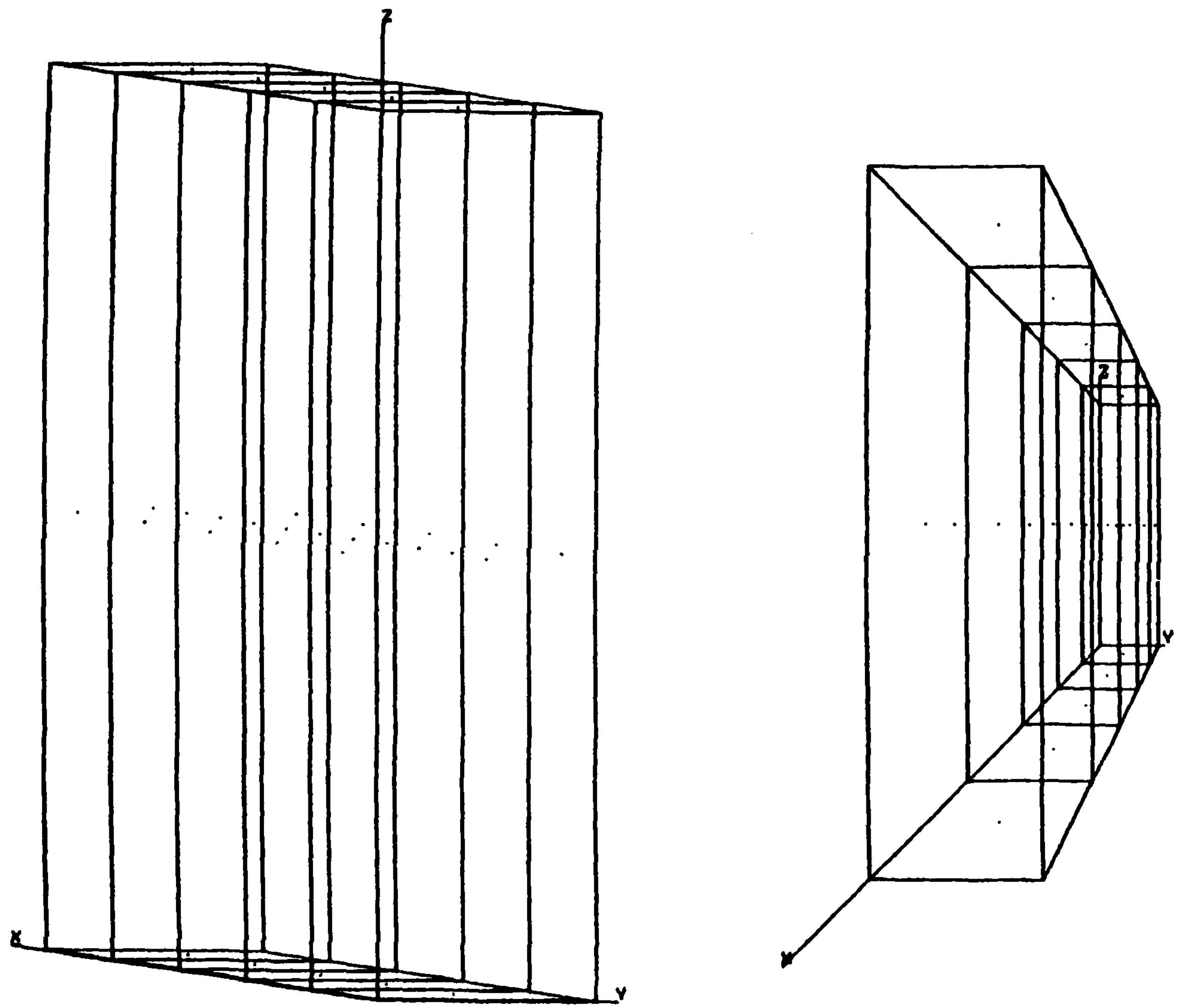


Figure 4.2.11. Illustration of the derivation of the 2 projection types, orthogonal and perspective.

parallel to the vertical axis remain vertical, and none of the other lines recede away from the viewer as in a perspective view. The perspective view causes all lines to recede, as shown in Figure 4.2.12. The default projection is perspective.



ORTHOGONAL VIEW (EYE AT 15., .25, .25)

PERSPECTIVE VIEW (EYE AT 15., .25, .25)

Figure 4.2.12. Two plots of the beam structure from the same eye position using (A) orthogonal projection and (B) perspective projection.

4.2.3.13 REFLECT (Figure 4.2.14)

REFLECT allows the user to reflect a plot about the yz-, xz-, or xy-plane. Both the original image and its reflection are plotted. Default is no reflection.

4.2.3.14 ROTATE (Figure 4.2.14)

ROTATE gives the user the chance to rotate the structure about the x-, y-, and z-axes. The user specifies a rotation angle, measured in degrees, for each axis. The angles are positive if they are counter-clockwise when looking down the positive side of the axis toward the origin. Default is no rotation.

4.2.3.15 SCALE (Figures 4.2.13 and 4.2.15)

PLOTBOB will map the 3-D structure onto a 2-D "virtual plane" as shown in Figure 4.2.13. The dimensions A and B, which have the same units of length as the structure, define a plane just large enough to contain the image. This

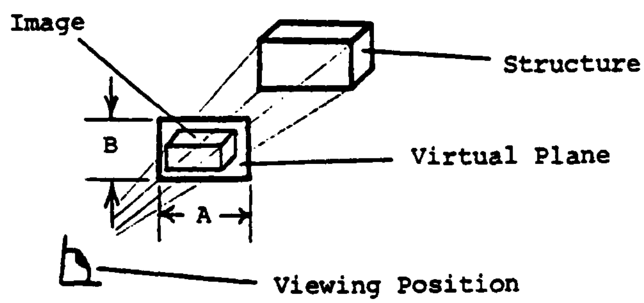


Figure 4.2.13. Illustration of the relationship between the virtual plane, the structure and the viewing position.

plane and the image on it must then be stretched and shrunk as necessary to fill the output device's bed or screen where it is to be viewed. This process naturally distorts the proportions of the final structure image, making it out of scale.

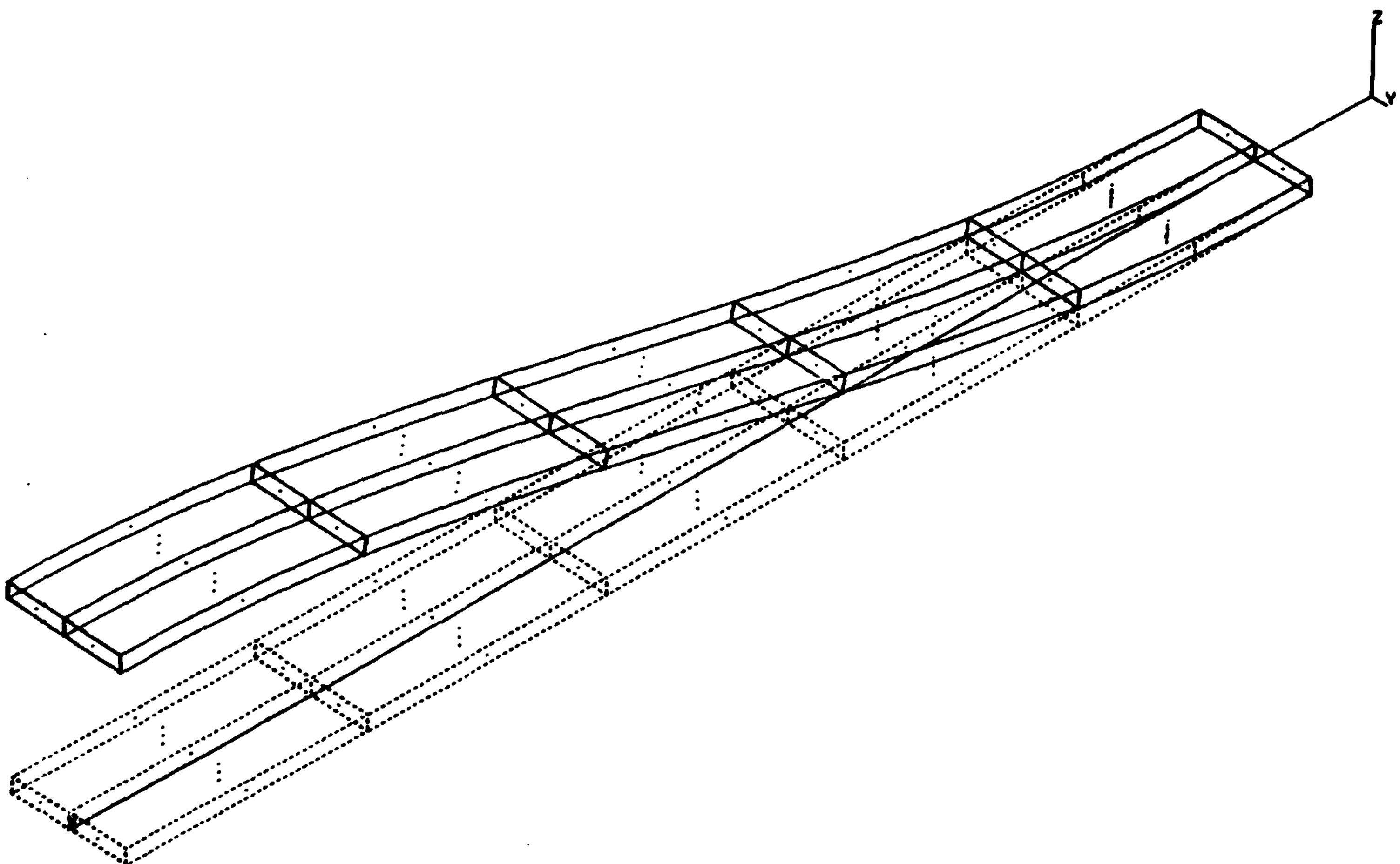
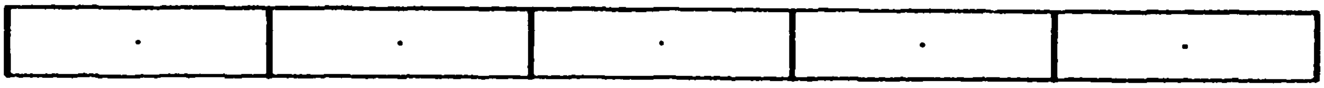
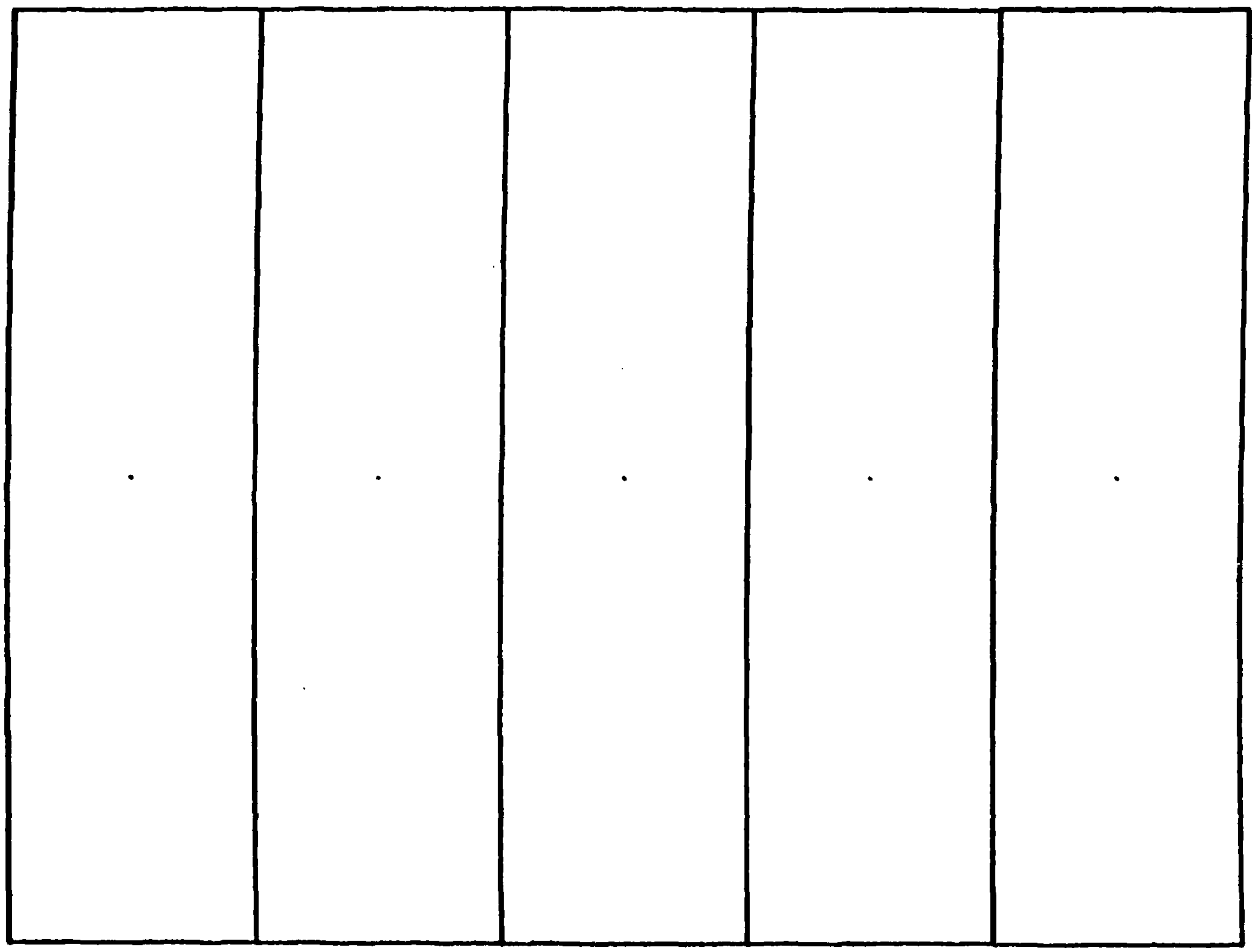


Figure 4.2.14. Plot of deformed and undeformed clamped beam structure illustrating TRANSLATE, ROTATE and REFLECT command. The original structure is illustrated in Figure 4.2.10.



A. SCALE



B. NON-SCALE

Figure 4.2.15. A clamped beam structure plotted (A) scaled and (B) nonscaled.

The purpose of the SCALE command, therefore, is to give the user an opportunity to view the final image with proper proportions. This is accomplished as follows:

For a Tektronix 4014 screen,

IF A > 1.33*B then B = 0.75*A

IF A < 1.33*B then A = 1.33*B

For an HP 7221 bed plotter,

IF A > 1.286*B then B = 0.778*A

IF A < 1.286*B then A = 1.286*B

This command allows the program to set the size of the virtual plane to be the same proportion as the plotter screen without changing the size of the image. The default for this command plots the structure with the proper scale for either PLOT10 or HPPLOT21 library users.

4.2.3.16 SHRINK (Figure 4.2.16)

Three basic shapes of elements are plotted by the program - beams (line segments), plates (planes), and six-sided solids. When a beam coincides with a plate or solid edge, or a plate coincides with a solid surface in multiple-element-type plots, the user cannot distinguish the various elements used and their locations. SHRINK gives the user an exploded view so that all elements may be seen clearly.

SHRINK achieves this by contracting the elements around their centroids, thus withdrawing them from all adjacent elements. The user specifies a shrink factor from 0 to 1 inclusive, with 0 being no shrinkage and 1 being shrinkage down to the centroid. SHRINK determines the centroid for each element and then determines the new location of each node according to the general formula.

$$P_{an} = C_a \cdot F_s + (1 - F_s) \cdot P_{ao}$$

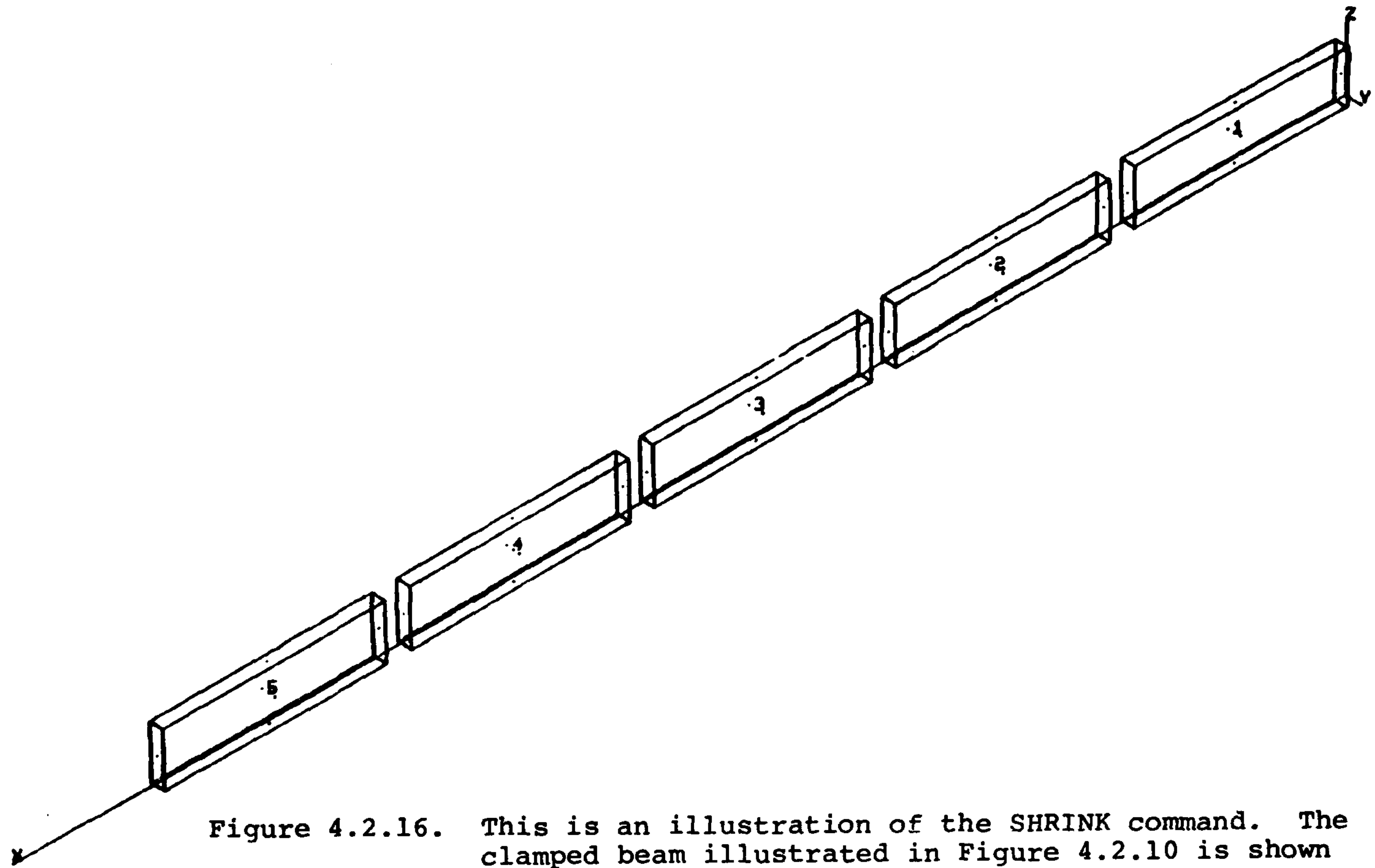


Figure 4.2.16. This is an illustration of the SHRINK command. The clamped beam illustrated in Figure 4.2.10 is shown here with the elements labeled.

where

P_{an} is the new node coordinate

P_{ao} is the old node coordinate

C_a is the centroid coordinate

F_s is the shrink factor.

A shrink factor of 0.1 works well. Default is no shrinkage.

4.2.3.17 STOP

Issuing a STOP terminates execution of the program.

4.2.3.18 SUMMARY (Figure 4.2.17)

SUMMARY lists the current options chosen by the user for each command.

4.2.3.19 TIME

When the user gives the TIME command on a CDC6600 computer, the computer prints the CPU time used in seconds, since the LOGIN was issued. Since the total available time for a session is typically limited to an installation-defined maximum, and since the user, after some experience, will know the approximate time for a plot, he can make a series of plots without exceeding the time limit.

4.2.3.20 TRANSLATE (Figure 4.2.14)

TRANSLATE translates a structure when the user specifies a translation vector. The units of the vector are the same as for the coordinates of the structure. Thus, if the user wishes to move the structure two units down the x-axis and five units up the z-axis, the user would enter 2.,0.,5. Default is no translation.

4.2.3.21 VERTICAL (Figure 4.2.6)

Using VERTICAL, the user can choose which axis (x, y, or z) should appear vertically on the plot.

```
LABEL AXES. . . . . . . .YES
LABEL ELEMENTS. . . . . .NO
LABEL NODES . . . . . . .NO
SCALE PLOT. . . . . . . .YES
PLOT ALL ELEMENTS . . . .YES
ZOOM OPTION . . . . . . .NO
AXIS VERTICAL . . . . . .Z-AXIS
PLANE REFLECTED . . . . .XY-PLANE
PROJECTION TYPE . . . . .PERSPECTIVE
CLIP PLANE FACTOR . . .       .0100
PLOT OPTION . . . . . . .UNDEF&DEF
SHRINK FACTOR . . . . .       0.0000
EYE POSITION:
    X-EYE=        100.0000
    Y-EYE=        100.0000
    Z-EYE=        100.0000
ORIGIN TRANSLATION:
  X=          1.0000
  Y=          0.0000
  Z=          0.0000
ROTATION:
  X-ANGLE=          90.0000
  Y-ANGLE=           0.0000
  Z-ANGLE=           0.0000
CUBE MINIMA AND MAXIMA:
  MINIMUM X    0.              MAXIMUM X    1.00000E+01
  MINIMUM Y    0.              MAXIMUM Y    1.25000E-01
  MINIMUM Z    0.              MAXIMUM Z    5.00000E-01
STRUCTURE NUMBER. . . .        1
UNDEFORMED MINIMA AND MAXIMA:
  MINIMUM X    0.              MAXIMUM X    1.00000E+01
  MINIMUM Y    0.              MAXIMUM Y    1.25000E-01
  MINIMUM Z    0.              MAXIMUM Z    5.00000E-01
DEFORMED MINIMA AND MAXIMA:
  MINIMUM X    0.              MAXIMUM X    1.00000E+01
  MINIMUM Y    0.              MAXIMUM Y    1.56200E+00
  MINIMUM Z   -1.54200E-08     MAXIMUM Z    5.00681E-01
INCREMENT NUMBER. . . .        1
DEFORM SCALE. . . . . .        3.0000
$
```

Figure 4.2.17. An example of the SUMMARY command.

The coordinates are adjusted accordingly when the user selects an axis other than the default z-axis for the vertical axis.

4.2.3.22 *ZOOM (Figure 4.2.18)*

ZOOM is the second command the user can employ in getting a blow-up of a portion of a structure. The structure must first be plotted with the view desired. Then the user specifies a virtual window which encloses that part of the plot on the screen the user desires to view more closely.

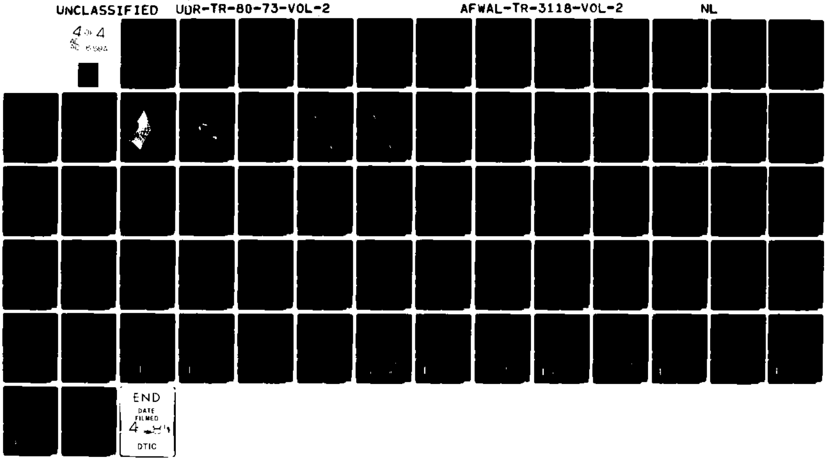
This is done with a Tektronix terminal using the cursor (two fine crossed lines which appear on the screen once the ZOOM command is implemented). The user adjusts the cursor to the location of the lower left-hand corner of the window he wishes to create using the cursor controls. He then enters any alphanumeric character from the terminal and depresses the "RETURN" key if the terminal is configured to require a carriage return. He repeats this procedure to define the upper right-hand corner of the window he wishes to create. The user may now plot the 'windowed' area at full scale on the screen or plotter.

To ZOOM on an HP7221 bed plotter the user must wait until the 'ENTER' light on the plotter control panel begins to flash; he then must move the pen to the lower left position of the ZOOM area with the pen controllers (buttons with arrows on them). To center the coordinate of the lower left corner the user must press the 'ENTER' button. This enters one x,y coordinate pair. The user must then move the pen to the upper right corner of the area to be expanded with the pen controllers and again press the 'ENTER' buttom. The program will take these two (x,y) coordinate pairs and create a 'window' onto which the zoomed area will be plotted. The user may now plot the structure.

To get a different view of the same area, the user must repeat the entire process. It should be noted that the final image is out of scale (the problem is similar to

AD-A096 594 DAYTON UNIV OH RESEARCH INST F/G 1/3
STRUCTURAL FLIGHT LOADS SIMULATION CAPABILITY. VOLUME II. STRUC--ETC(U)
NOV 80 T S BRUNER, M P BOUCHARD, J G GEBARA F33615-76-C-3135
UNCLASSIFIED UDR-TR-80-73-VOL-2 AFWAL-TR-3118-VOL-2 NL

4 of 4
AD
A096594



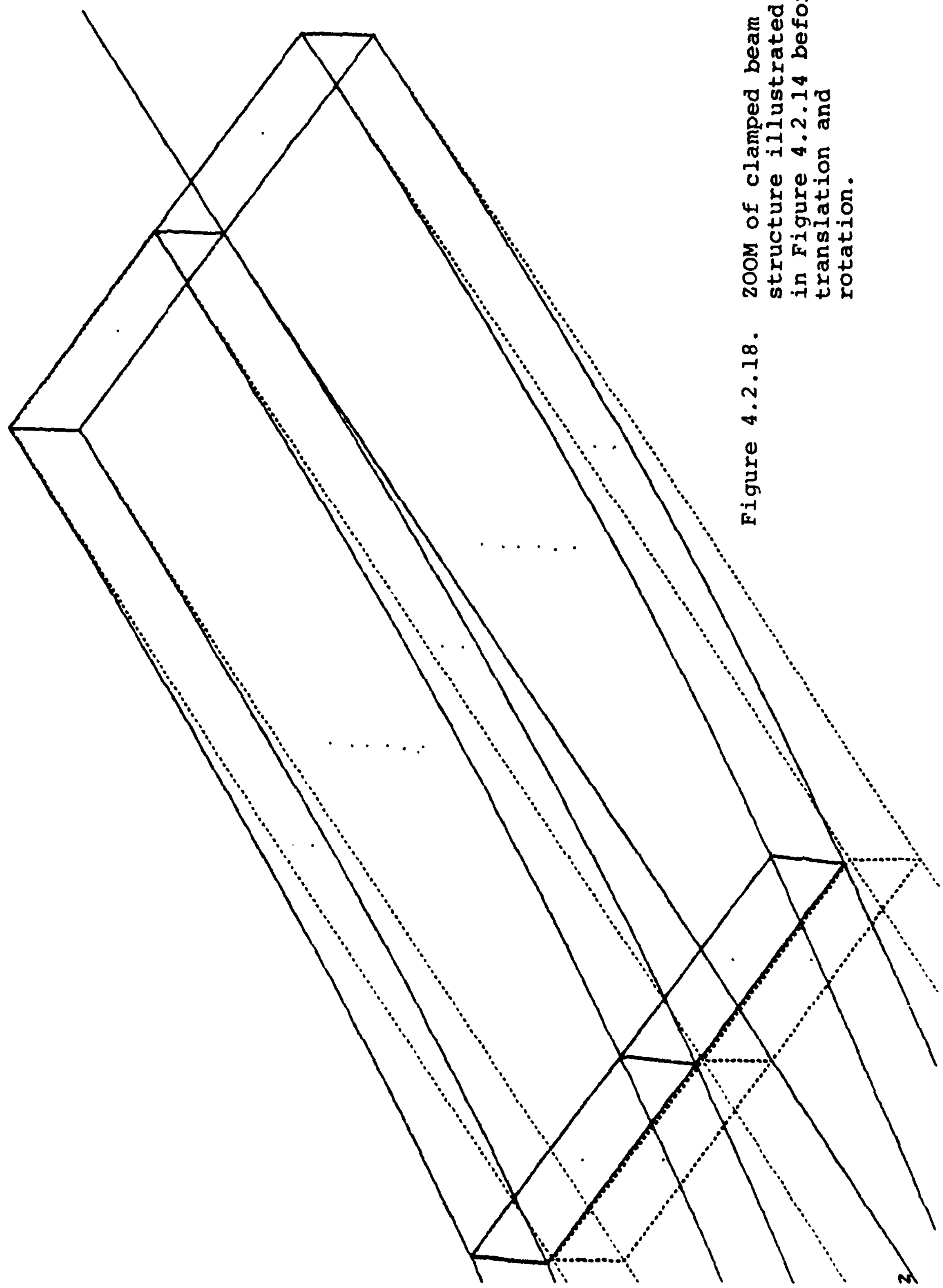


Figure 4.2.18. ZOOM of clamped beam structure illustrated in Figure 4.2.14 before translation and rotation.

the one of the virtual plane being mapped onto the screen, as described in SCALE). Refer to the CUBE command for an alternative method of enlarging a specific area of a model. It is important to make sure your terminal or plotter has digitizing capability prior to executing this command.

4.3 CONTOUR - INTRODUCTION

CONTOUR is an interactive computer program for the graphical display of data obtained through finite element model analysis. CONTOUR displays data either in the form of contours, relief maps or some combination of the two. It is structured in such a way as to make the execution of the program as simple as possible. CONTOUR's capabilities include:

- plotting of stress, strain or displacements contours,
- labeling of contours,
- plotting of relief maps of stress, strain or displacement,
- undeformed and deformed structure plotting,
- variable contour quantity and quality,
- variable 3-D views,
- exploded views for easier model comprehension,
- zooming,
- selective element plotting,
- descriptive plot labeling.

CONTOUR is used only with MAGNA analysis output files (-MPOST files) and proves to be most effective for high quality 'finished' contour and displacement plots of the finite element model. Further plotting capabilities are detailed in Section 4.2 - PLOTBOB plotting program.

4.3.1 Procedure for Executing

CONTOUR is executed by utilizing a command procedure as illustrated below:

```
LOGIN......
ATTACH,F,PLOTTINGPROCEDURES,ID=XXXX,SN=XXXX
ATTACH,TAPE99,pfn   (desired -MPOST file)
BEGIN,PLOT,F        (,H is added for HP 7221 plotter)
                    (blank for Tektronix terminal)
```

PLOTTINGPROCEDURES is a job control procedure which performs all tasks associated with executing CONTOUR. The parameters on the BEGIN command specify whether the user is utilizing a graphics terminal with PLOT10 software (Tektronix) or a bed plotter with HPPLOT21 software (Hewlett-Packard). If a graphics terminal is being used only the command BEGIN,PLOT,F. is required. For use of the program with a bed plotter an additional parameter is required as follows: BEGIN,PLOT,F,H. to utilize the proper graphics commands.

4.3.2 Command Structure

The execution of CONTOUR plotting program is achieved in two phases: Part I - Data Initialization and Part II - Command Directives. Data Initialization identifies the data set to be plotted and subsets of the data file to be utilized. Command Directives control the actual plotting including selection of viewing angles, element plotting, contour and relief maps, etc. Use of the NEST and NEWD commands will return the user to the Data Initialization phase. All other commands will control the data set established by the previous Data Initialization phase.

4.3.3 Data Initialization

This phase of CONTOUR defines the data set to be plotted. The program will prompt the user with a series of questions to direct the input of the correct data for the plots desired. These questions are:

STRUCTURE NUMBER?

NUMBER OF ELEMENT TYPES TO BE AVERAGED?

ELEMENT TYPES TO BE USED IN COMPUTING
SMOOTHED VALUES?

ELEMENT TYPE 3 SUBTYPE?

VALUE PLOT OPTION?

DO YOU WISH TO LIST NODAL VALUES?

STRESS/STRAIN (if stress or strain chosen above)

INCREMENT NUMBER?

The Structure number pertains to the order in which the structure to be plotted appears on the -MPOST file. Most cases will involve only one structure per nonlinear analysis and possibly several structures for a linear analysis.

MAGNA will generate stress, strain and displacement values at selected points within each element. In order to generate approximate values for stress strain or displacement CONTOUR extrapolates these interior "integration" values to the nodes. Since each node may be utilized in several different elements it is best to average all the nodal values obtained from extrapolating from integration points to a common node from the same element type. If a node is included in more than one element type, the user should only average one of those element types at a time to get a true representation of the stresses, strains and displacements on that node due to the various components. For Wing model plotting the user will wish to average either element types 3 or element type 5. (if shell elements were used) but only one at a time. In structures where several element types are used that do not involve common nodes more than one element type may be averaged at a time.

Once the user determines how many element types he wishes to average he is asked to input the actual element types he wishes to average. The number of ELEMENT TYPES TO BE USED IN COMPUTING SMOOTHED VALUES must correspond to the value entered for the question NUMBER OF ELEMENT TYPES TO BE AVERAGED?

If element type 3 is used above the program will request a subtype: ELEMENT TYPE3 SUBTYPE? There are three subtypes available:

1 = plane stress
2 = plane strain
3 = shear panel.

The subtype requested must be included in the model data. The model will always have subtype 3 and will utilize subtype 1 if no shell elements are generated.

A VALUE PLOT OPTION is requested by the program to determine what type of information will be plotted. The value plot option may be one of four choices:

0 = stress or strain plot
1 = x displacement plot
2 = y displacement plot
3 = z displacement plot.

Should the user select 0, stress or strain plot, a question will follow later requesting the stress or strain code (see below).

Occasionally, it is important to know the actual values of the nodes as determined by utilizing the integration points and averaging the values. DO YOU WISH TO LIST NODAL VALUES? provides the user with the option of having a list of these values printed at the terminal once the data set has been defined and before any plotting commands may be initiated.

The STRESS/STRAIN CODE is requested if the user responded that he wishes to plot stresses or strains (option 0 to question of VALUE PLOT OPTION). The following 13 codes are value stress/strain codes:

1 = EXX	2 = EYY	3 = EZZ
4 = EYZ	5 = EXZ	6 = EXY
7 = SXX	8 = SYY	9 = SZZ
10 = SYZ	11 = SXZ	12 = SXY
13 = equivalent stress		

where E = strain components
and S = stress components

One of the above codes must be selected. The program cannot determine whether a selected code will generate the proper stresses and strains for the element type selected and its orientation in space, this is up to the user to determine.

The last question to be answered in this part is which increment of the data set the user wishes to plot. Increments are established as either time intervals of a time dependent analysis or as a load interval for multi-step loading analysis. Each time interval or load increment is considered a data increment and ranges from 1 (for most linear static analyses) to N where N can be any number of intervals the user selects. Twenty intervals are suggested for a nonlinear static analysis of wing models.

4.3.4 Command Summary

This second phase of CONTOUR execution allows the user the use of various plotting options to most effectively view the data set established in the first phase above. These commands may also allow the user to alter the data set or select a new increment or structure for plotting. If the user desires to return to phase one described above he can enter the commands NEWD or NEWS as desired.

Commands are entered as four letter keywords which prompts the program to request the pertinent information to alter the plot. Any number of commands may be executed and any command may be executed any number of times until the plots are to the user's satisfaction. CONTOUR has been designed in such a way that no commands will be necessary unless the user wishes to alter a default parameter. The remainder of this section lists each command alphabetically and explains its use. Figure 4.3.1 provides a list of the commands discussed. Should the user desire additional information, he may refer to similar commands discussed in Section 4.2 for PLOTBOB.

4.3.4.1 ALEL

The user, employing the ALEL command, can choose which elements he wishes to plot. After entering the number of different element types to be plotted, the program requests the first element type from which to select elements for plotting. The available element types are

CONTROL COMMANDS
******* ********

COMMAND	FUNCTION
NEST	PREPARE NEW STRUCTURE DATA
NEWD	PREPARE NEW DATA SET FOR PLOTTING
CUBE	CHANGE MAX/MIN VALUES
TIME	PRINT CURRENT CPU TIME USED
EXIT	EXIT PROGRAM
PLOT	PLOT WITH PRESENT DATA
HELP	PRINT COMMAND OPTIONS AND FUNCTION
RESE	RESET TO DEFAULT OPTIONS
SUMM	PRINT THE CURRENT OPTION CONDITION
WAIT	PUT PROGRAM INTO PAUSE

OPTIONS
****

COMMAND	FUNCTION	DEFAULT
LELE	LABEL ELEMENTS	NO
LAXS	LABEL AXIS	NO
LABE	PLOT TITLE BLOCK	NO
ALEL	PLOT ONLY SOME ELEMENTS	NO
ENTE	PLOT ENTIRE ELEMENT	NO
EXPL	PLOT EXPLODED VIEW	NO
ZOOM	EXPAND AREA OF INTEREST	NO
POSA	PLOT A POSITIVE ARROW	NO
SUBT	SUBTITLE IN TITLE BLOCK	NO
DEFO	SELECT GEOMETRY	UNDEFORMED
CORE	SELECT CONTOUR OR RELIEF	CONTOUR
CLIP	DISTANCE TO CLIP PLANE	.01
EYEP	SELECT EYE POSTION	100,100,100
SITE	CHANGE SITE POSTION	CENTROID
VERT	SELECT VERTICAL AXIS	Z
REFL	SELECT A REFLECT OPTION	NONE
PROJ	SELECT PROJECTION TYPE	PERSPECT.
SURF	SELECT PLOTTING SURFACE	6
CONL	LABEL CONTOURS	NO
STEP	CHANGE STEP SIZE	.05
NODE	LABEL NODES	NO

Figure 4.3.1. List of commands available for CONTOUR.

TYPE	DESCRIPTION
1	Variable number of nodes solid (up to 27 nodes)
2	Eight node brick
3*	Four node plate element
4*	Two node bar element
5*	Eight node shell element
6	Twenty node solid element
7	Variable number of nodes solid (up to 20 nodes)
8	Sixteen node solid element

*denotes element types used for wing modeling.

Of course, not every structure will contain all of these, so the user must be familiar with the data he wishes to plot. After this step, the user enters the elements of his choice using one of three methods.

Method 1 - Select random elements by entering the number of elements to be plotted followed by the element numbers themselves.

Example - entering 4, 1, 8, 10, 23 would plot four elements, numbers 1, 8, 10, and 23.

Method 2 - Select a range of elements by entering the first and last element in the range, followed by an increment number.

Example - entering 1, 13, 3 would plot elements 1, 4, 7, 10, and 13.

Method 3 - Plot all of the elements for the present type. Elements are numbered consecutively through each element type. Thus, if a structure consists of fifteen type 1 elements and five type 2 elements, the first set of elements would be numbered 1 through 15, and the second, 16 through 20. This procedure is then repeated for the next element type and so on, until all the elements the user desires to plot have been entered. The default is that all elements for all types present are plotted.

4.3.4.2 CLIP (Figure 4.3.2)

The CLIP command allows the user to designate the distance from the eye to the clip plane.

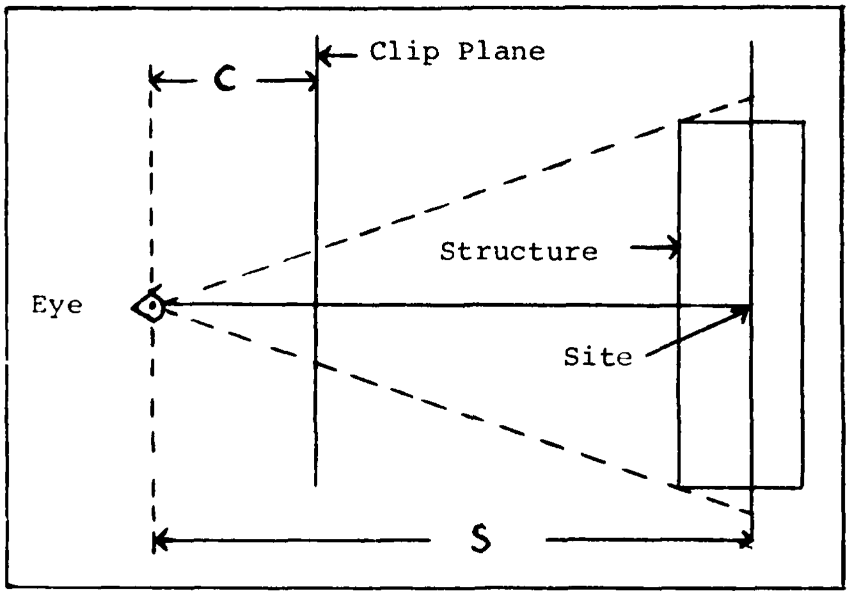


Figure 4.3.2. Illustration of how to define a clip plane for the CLIP command.

The distance is defined by the ratio c/s, where c is the distance from the eye to the clip plane and s is the distance from the eye to the site. Any part of the structure that is closer to the eye than the clip plane will be clipped. This is espectially useful for viewing inside or very close to the structure. The default value is .01. The distance should never be greater than one, and depending on the eye position should be a fairly small number.

4.3.4.3 CONL (Figures 4.3.3 and 4.3.9)

The CONL command lables the contours so the user can easily identify values of the contours. When both CONL and LABE options are active, a table of contour values is printed in the lower right hand side of the plot.

4.3.4.4 CORE (Figures 4.3.3 and 4.3.4)

The CORE command allows the user the choice of plotting either relief maps, contour plots or both.

A relief map consists of a surface constructed above and below the plotting surface. At each point the surface is scaled proportional to the value of the component being plotted at that point. The relief map is scaled so the maximum displacement from the surface is the relief scale.

A contour plot consists of contours of equal value. The value is that of the component being plotted. These contours are drawn in incremental steps (see STEP command), the values for which are designated by the user. The contours can also be labeled (see CONL command).

If the user selects the contour option, the user will be given the maximum and the minimum value of the component being plotted. The user will then be asked to enter minimum, maximum and increment values for the contours. If the increment value is zero, the input minimum and maximum values are ignored and the component max and min are used with a computed increment such that ten contours are plotted.

If the user selects the relief option, the user will be asked to input the number of lines per element (NLIN). NLIN must be greater than 1, and determines how fine the relief map is. The number of lines that should be chosen depends on how large the elements appear on the plots, for larger elements more lines are suitable.

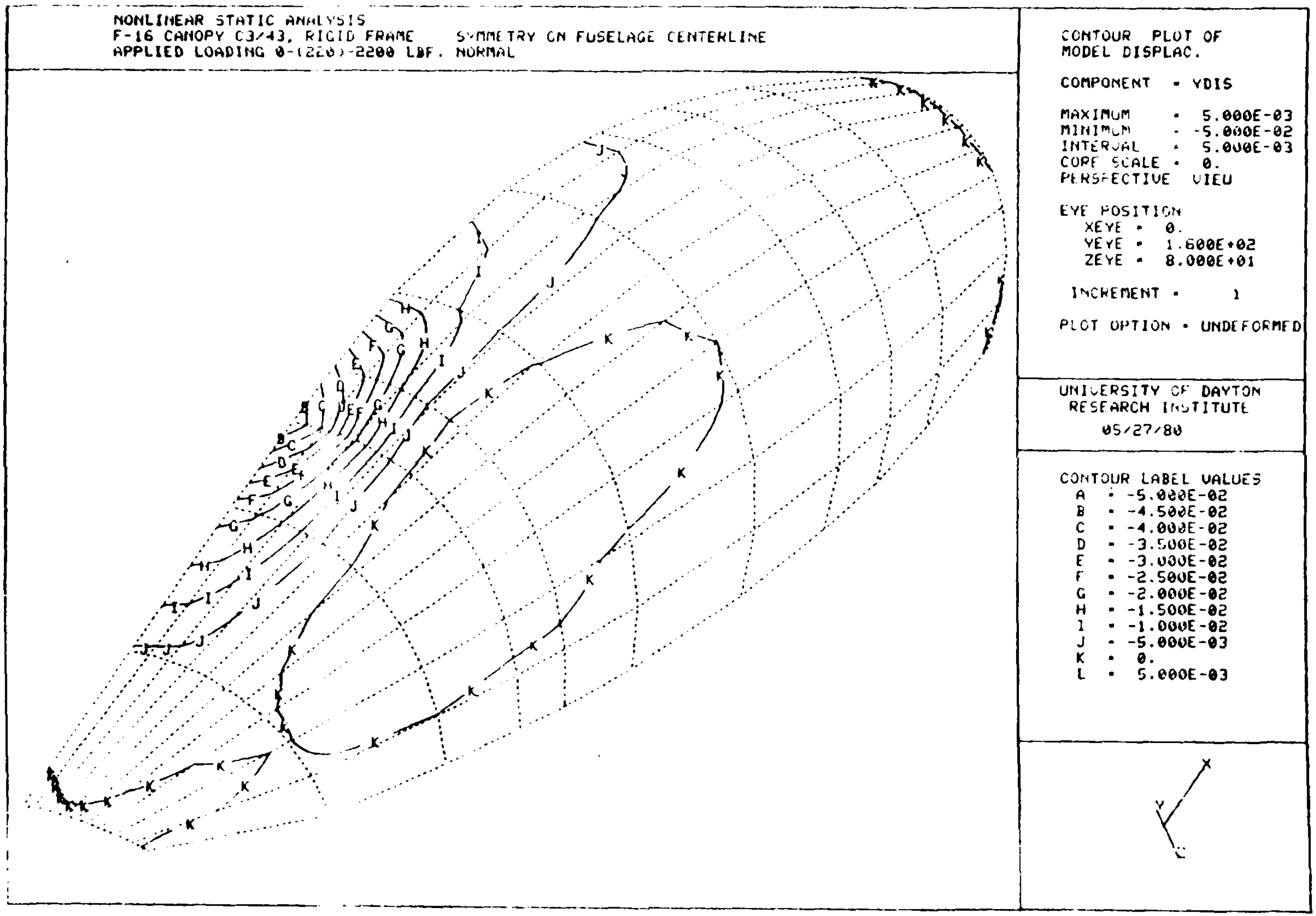


Figure 4.3.3. Contours lines are labeled in this contour plot of an F-16 canopy.

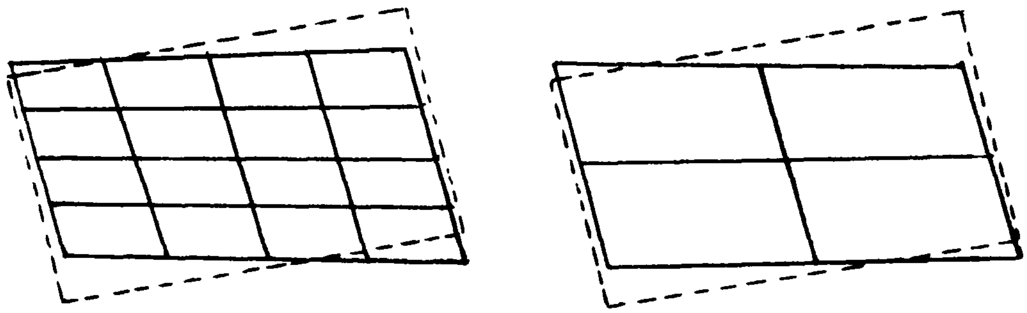


Figure 4.3.4. The CORE command allows the user to select the number of lines per element that may be utilized in highlighting the structure. The use of these lines is illustrated in Figure 4.3.5.

The last parameter requested of the user is the relief scale. The relief scale is the maximum number of units above or below the element surface the relief map can be. If the contour only or the contour and relief option is used the contour will be scaled off the surface. In the contour and relief option, this results in having the contours drawn on the relief map. In the contour option this results in having the contours drawn scaled off the surface.

The default value is contour only with the minimum and maximum being the component minimum and maximum and the increment computed so ten contours are plotted. The default for the relief scale is zero.

4.3.4.5 CUBE

The CUBE command allows the user to change and minimum and maximum x, y and z coordinates. This command can be used either to zoom in on a particular section or to pan out. Using CUBE to zoom has an advantage over the ZOOM command of having the plot automatically scaled. Also included in the CUBE command is a change of site; for more information see the SITE command.

4.3.4.6 DEFO (Figures 4.3.5a-c and 4.3.6a-b)

The DEFO command allows the user to decide to plot the undeformed structure, the deformed structure or both. If the user chooses to plot a deformed structure, a scale factor must also be input. The displacements will be multiplied by the scale factor before the displacement is added to the undeformed structure. The outline of either the deformed or undeformed structure, when plotted alone, will be dotted, but when they are plotted together, the undeformed is in solid lines and the deformed is dotted. The default for this option is undeformed.

4.3.4.7 ENTE (Figure 4.3.6b)

The ENTE command enables the user the choice of plotting the entire element outline or just the designated surface. If the user selects to plot the entire element for element types 1, 2, 5, 6, 7 and 8, a rectangular prism will be drawn. See SURF command for further information on surfaces. The default is to just plot the surface 6.

4.3.4.8 EXIT

The EXIT command is used to exit the program.

4.3.4.9 EXPL (Figure 4.3.7)

The EXPL command gives the user a method of separating the elements from each other so the plot can be more easily understood. If the user chooses to plot an exploded view, a scale factor must be entered. This factor is defined as being 1-B/A where A is the original distance from a node to the centroid of the element and B is the desired distance from the node to the centroid. It is suggested that the factor be between .25 and .1. In this range the elements are usually distinguishable and yet large enough to be seen.

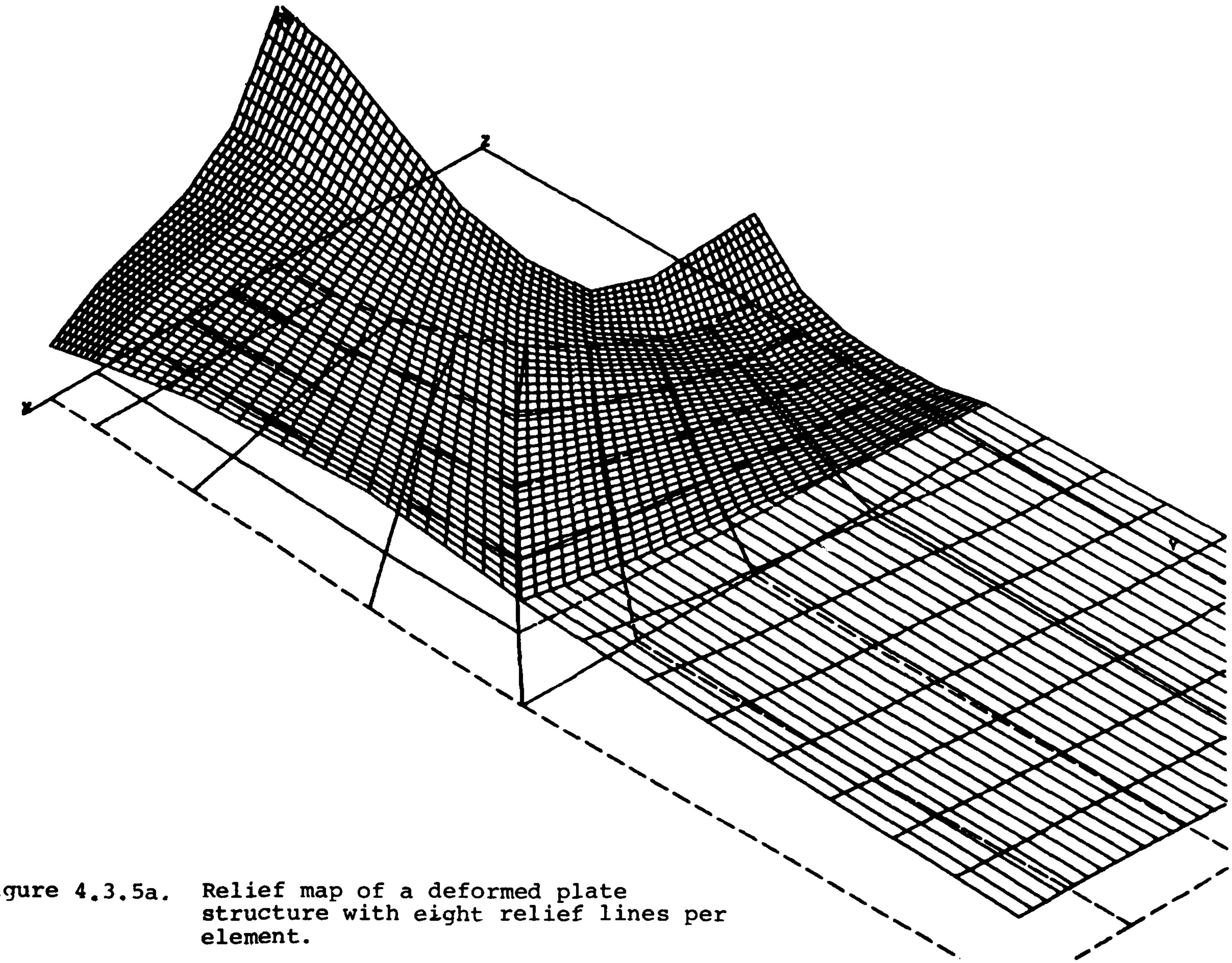


Figure 4.3.5a. Relief map of a deformed plate structure with eight relief lines per element.

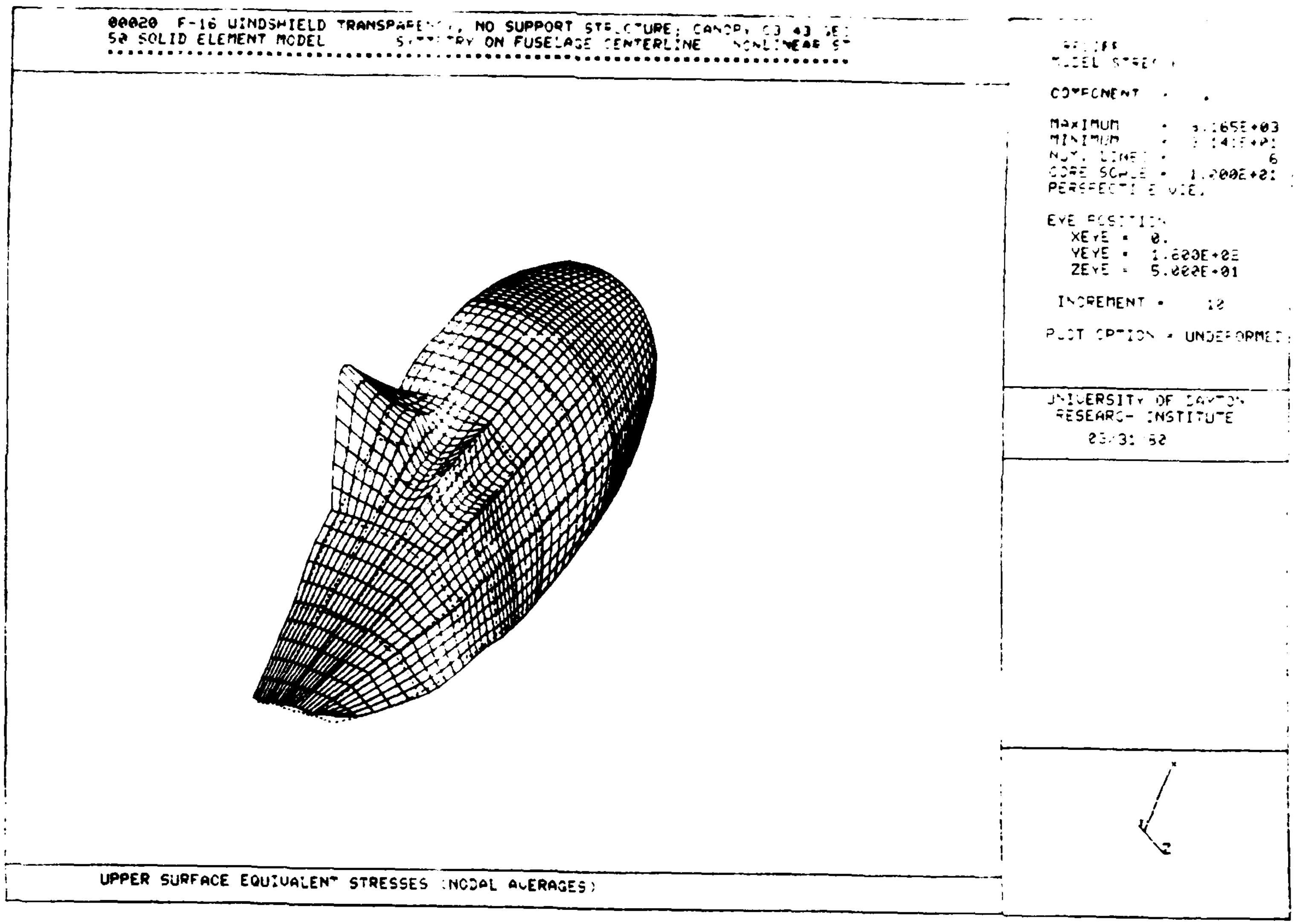


Figure 4.3.5b. Relief map of a deformed F-16 windshield canopy with five relief lines per element.

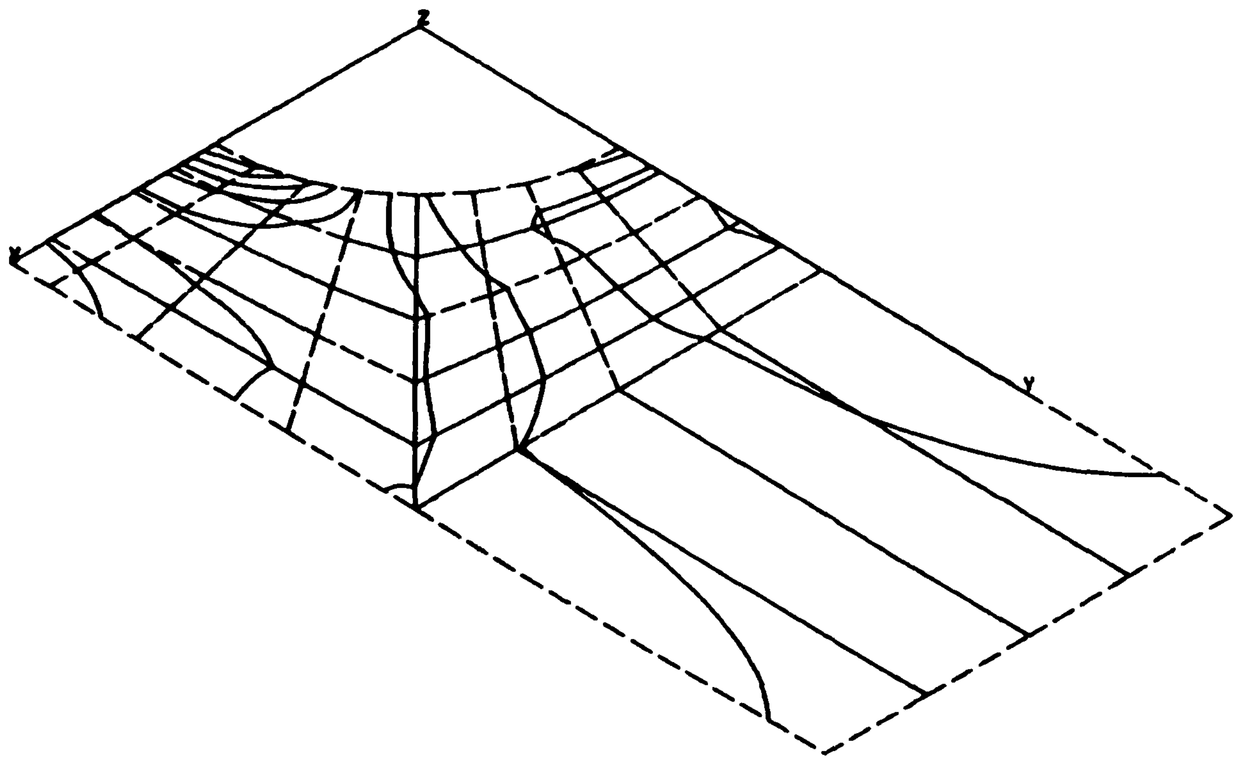


Figure 4.3.5c. Contour map of stress on a loaded plate structure.

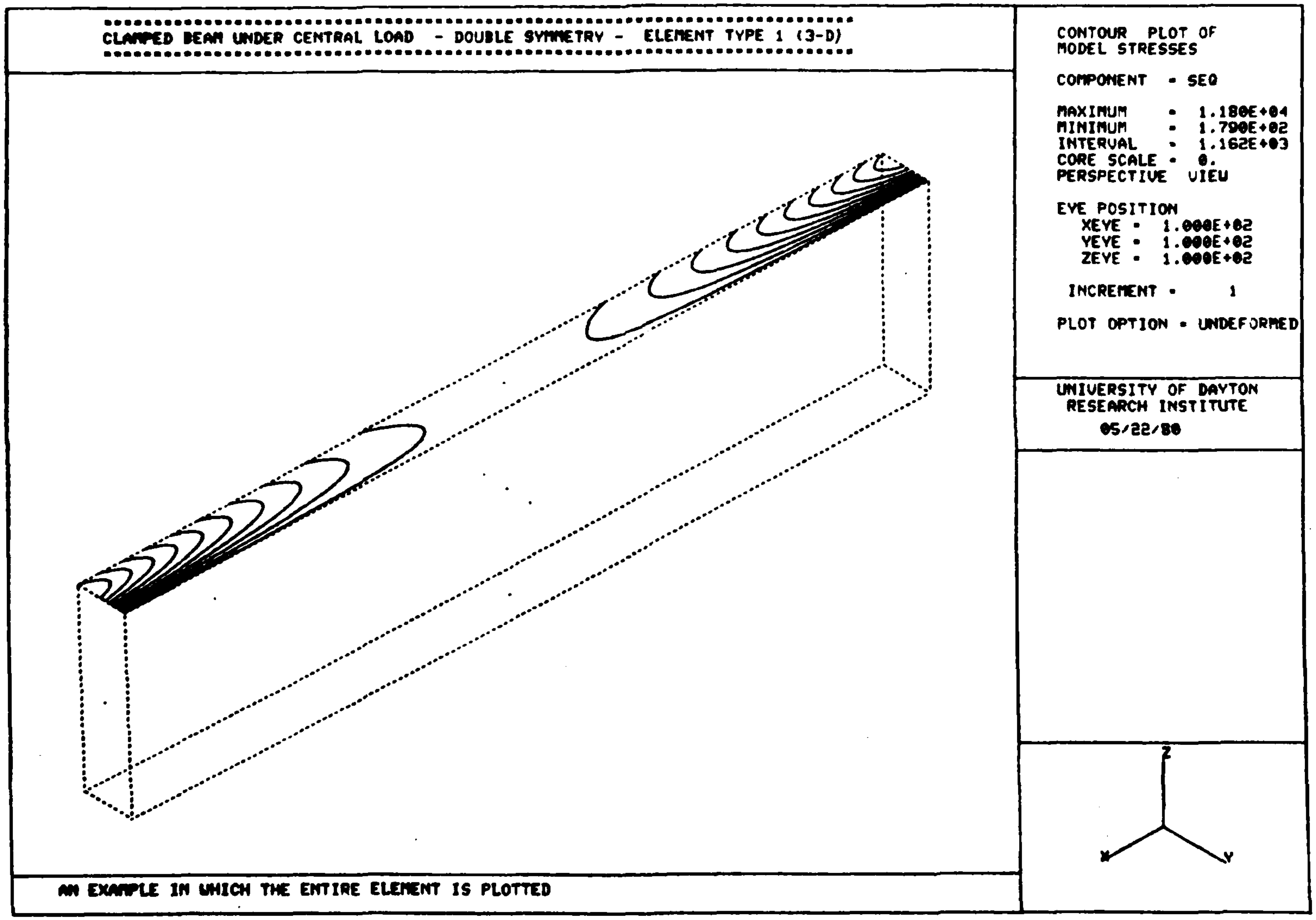


Figure 4.3.6a. Contour plot of a single undeformed 3-D element with all surfaces plotted.

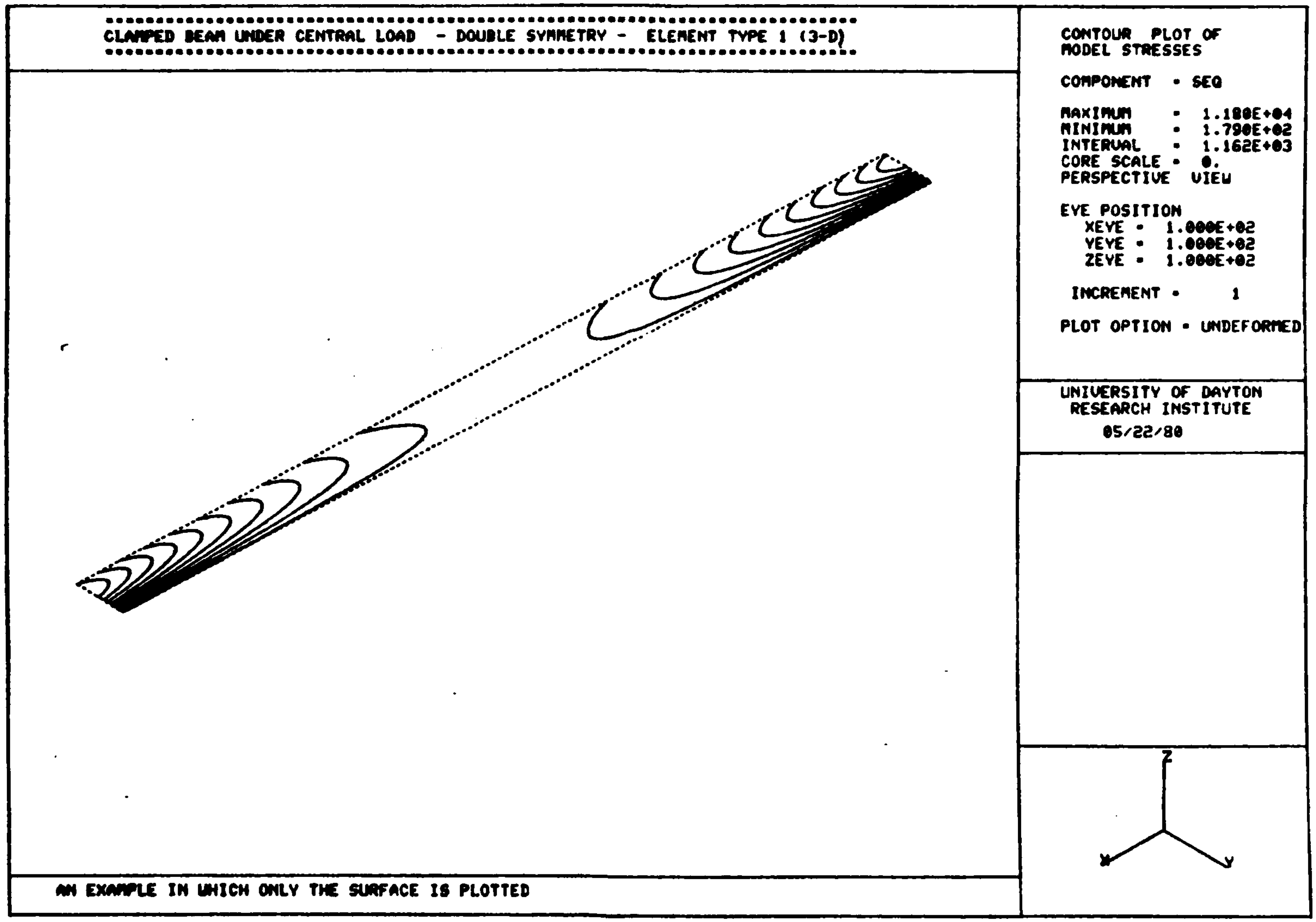


Figure 4.3.6b. Contour plot of a simple undeformed 3-D element with only one surface plotted (surface #6). See ENTE command.

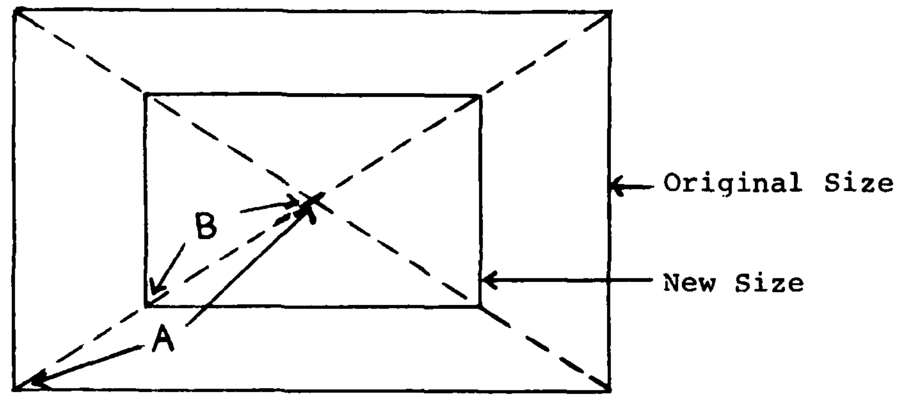


Figure 4.3.7. This figure defines the parameters used in shrinking the elements for exploded views. Refer to the EXPL command.

4.3.4.10 EYEP

The EYEP command allows the user to change his eye position. The eye position is given in x, y, z global coordinates, that is, the coordinates used to define nodal positions. The default eye position is 100,100,100. The user should be careful in choosing the eye position. If the eye position is too close to the structure, the plot will be clipped by the clip plane.

4.3.4.11 HELP (Figure 4.3.8)

The HELP command gives a list of the commands, and a short description of their function. Figure 4.3.8 lists the commands and their default values.

4.3.4.12 LABE (Figures 4.3.5, 4.3.6 and 4.3.9)

The LABE command enables the user to label the plot which will help in plot identification. The label, as seen in the figure, identifies the structure, the type of plot, the stress, strain or displacement plotted, the view and if desired, contour values and/or a subtitle. The title of the structure, which appears at the top of the plot, consists of the first three lines of the mpost file. These

CONTROL COMMANDS
******* ********

COMMAND	FUNCTION
NEST	PREPARE NEW STRUCTURE DATA
NEWD	PREPARE NEW DATA SET FOR PLOTTING
CUBE	CHANGE MAX/MIN VALUES
TIME	PRINT CURRENT CPU TIME USED
EXIT	EXIT PROGRAM
PLOT	PLOT WITH PRESENT DATA
HELP	PRINT COMMAND OPTIONS AND FUNCTION
RESE	RESET TO DEFAULT OPTIONS
SUMM	PRINT THE CURRENT OPTION CONDITION
WAIT	PUT PROGRAM INTO PAUSE

OPTIONS
****

COMMAND	FUNCTION	DEFAULT
LELE	LABEL ELEMENTS	NO
LAXS	LABEL AXIS	NO
LABE	PLOT TITLE BLOCK	NO
ALEL	PLOT ONLY SOME ELEMENTS	NO
ENTE	PLOT ENTIRE ELEMENT	NO
EXPL	PLOT EXPLODED VIEW	NO
ZOOM	EXPAND AREA OF INTEREST	NO
POSA	PLOT A POSITIVE ARROW	NO
SUBT	SUBTITLE IN TITLE BLOCK	NO
DEFO	SELECT GEOMETRY	UNDEFORMED
CORE	SELECT CONTOUR OR RELIEF	CONTOUR
CLIP	DISTANCE TO CLIP PLANE	.01
EYEP	SELECT EYE POSTION	100,100,100
SITE	CHANGE SITE POSTION	CENTROID
VERT	SELECT VERTICAL AXIS	Z
REFL	SELECT A REFLECT OPTION	NONE
PROJ	SELECT PROJECTION TYPE	PERSPECT.
SURF	SELECT PLOTTING SURFACE	6
CONL	LABEL CONTOURS	NO
STEP	CHANGE STEP SIZE	.05
NODE	LABEL NODES	NO

Figure 4.3.8. This list is obtained by executing the HELP command.

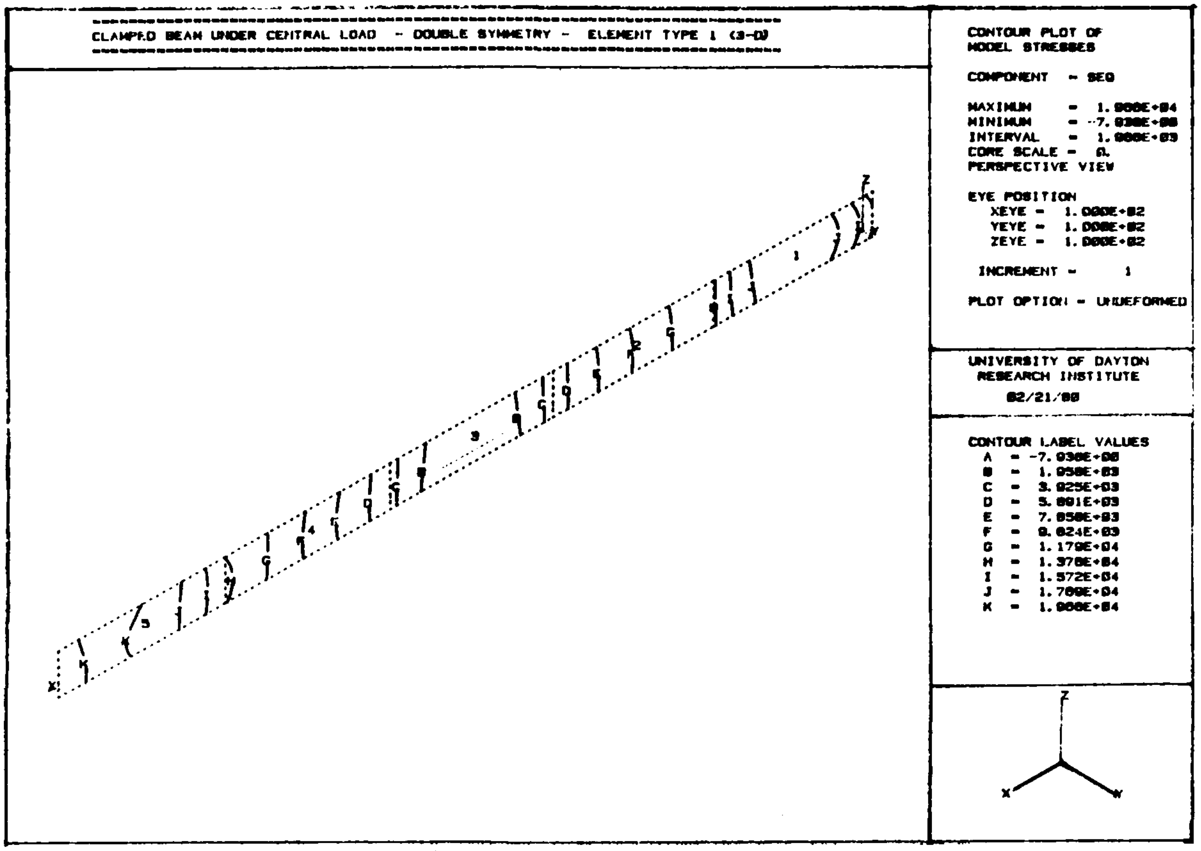


Figure 4.3.9. This illustration demonstrates the LABE command allowing the plot to be well-documented with necessary plot information. The CONL command was also invoked to label the contours.

lines originate from the beginning of the input file and may be up to eighty characters. The type of plot is designated by telling if the plot is contour, relief, or both. The components of stress or strain are given using the codes described in Section 4.3.3. When displacements are plotted, DIS is used with the direction. The eye position, view, minimum and maximum of component plotted and certain plot parameters are also given. The contour label values and subtitle are discussed in the CONL and SUBT commands respectively.

4.3.4.13 LAXS (Figure 4.3.5a)

The LAXS command allows the user to plot the x, y and z axis. This can be useful in determining the orientation of the structure. The axis will be drawn from the (0,0,0) point to the maximum point on each axis. The coordinates used are global coordinates, that is, the coordinates used to define elements.

4.3.4.14 LELE (Figure 4.3.9)

The LELE command allows the user to number the elements. The elements are numbered starting with the first element type used and numbered consecutively through element types. When a reflect option is used the reflected elements are numbered from where the unreflected elements ended. NOTE: Element numbers remain constant from preprocessor generation through analysis and into postprocessor plotting.

4.3.4.15 NEST

The NEST command allows the user to plot more than one structure on the same file. The NEST command sets all the parameters to their default values and returns to the beginning of the program. See Section 4.3.2.

4.3.4.16 NEWD

The NEWD command allows the user to change the data set being plotted. The NEWD command does not change the plotting parameters. See Section 4.3.2.

4.3.4.17 NODE

The NODE command allows the user to label nodes. Depending on whether or not the entire element is to be plotted, either only the surface nodes or all the nodes may be plotted. For more information about the surface, consult the SURF command.

4.3.4.18 PLOT

The PLOT command generates a plot with the current data set and parameters.

4.3.4.19 POSA (Figure 4.3.10)

The POSA command allows the user to determine the positive direction on a relief plot. When an

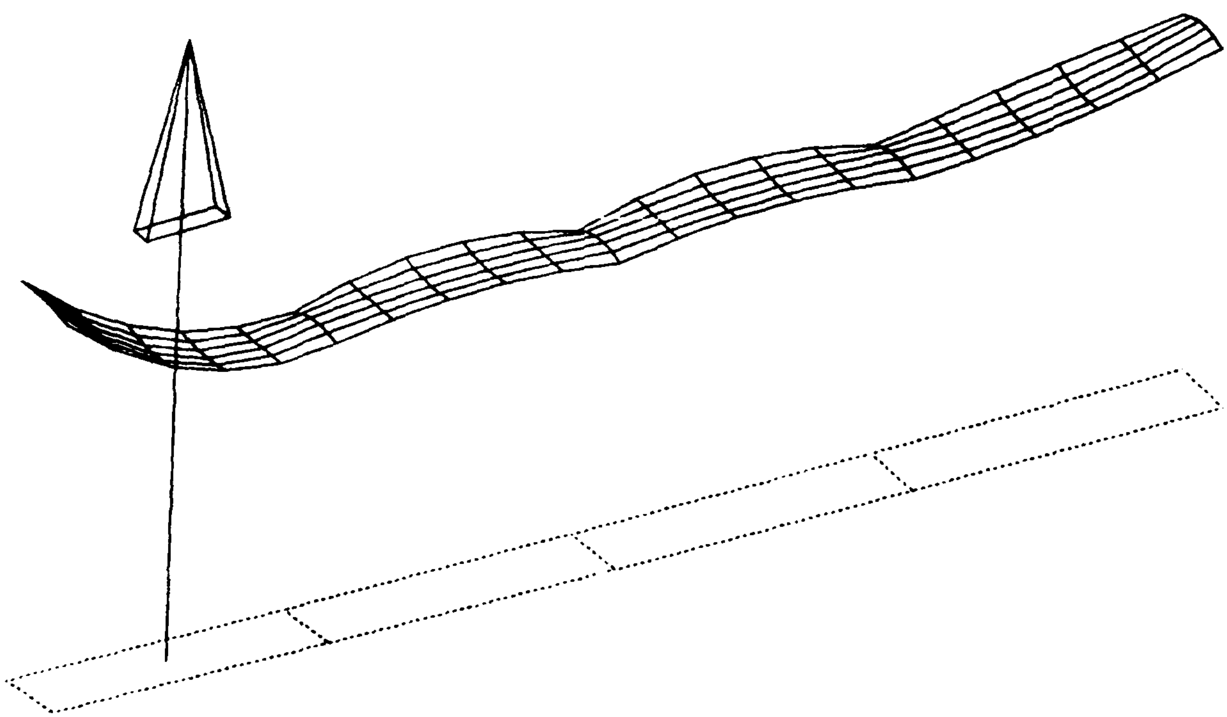


Figure 4.3.10. A positive direction arrow will be drawn by the POSA command to inform the user in which direction positive stresses, strains or displacements occur.

arrow is desired, it will appear in the center of the first element plotted, and will point in the positive direction. For example, this option should be used when there is a question as to whether a stress represents compression or tension.

4.3.4.20 PROJ (Figure 4.3.11)

The PROJ command allows the user to chose between an orthogonal or a perspective view. An orthogonal view occurs when the lines of projection of an image are drawn perpendicular to the projection plane whereas a perspective view occurs from drawing projection lines from an image straight to the eye position of the viewer and being intercepted by a projection plane. The perspective view tends to distort the

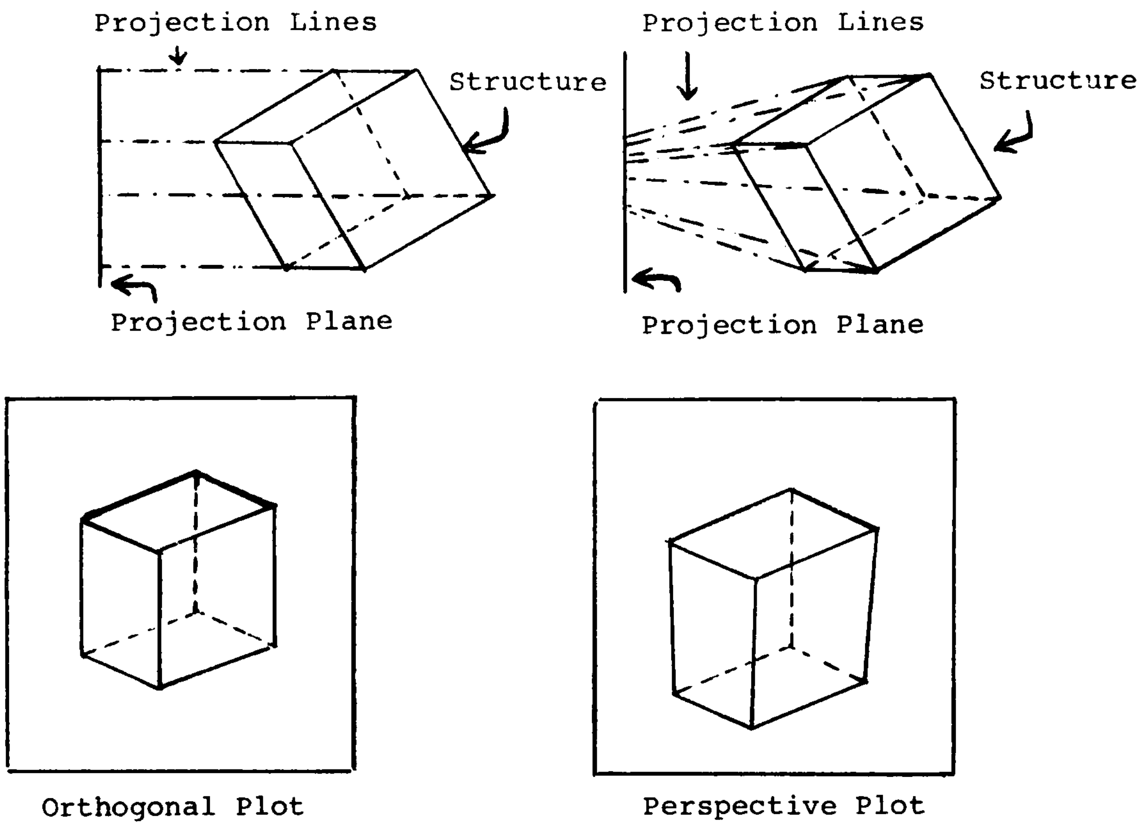


Figure 4.3.11. This figure illustrates the differences between orthogonal and perspective projections.

structure, so the elements closer to the eye appear larger than the elements further away from the eye. The default is perspective.

4.3.4.21 REFL (Figure 4.2.14)

The REFL command allows the user to plot the structure plus a reflected image. The possible reflect options are x, y, z or none. If x, y or z are chosen the image is reflected along the indicated axis.

4.3.4.22 RESE

The RESE command resets all the plotting parameters to their default values. For a list of the default values see the HELP command.

4.3.4.23 SITE

The SITE command allows the user to change the site position of the structure. The site position is the position in the structure that appears in the center of the plot. By changing the site position, the user can concentrate his attention on a specific section of the structure. When using the CUBE command, the site position is adjusted to the centroid of the new maximum and minimum unless otherwise specified.

4.3.4.24 STEP (Figure 4.3.12)

The STEP command allows the user to produce more accurate contours. The step size is the distance from one point on a contour to the next. The distance is measured in local element coordinates. This step will be in either the positive or negative x or y direction. The default value is .05. The suggested values for the step are between .1 and .01. The user should be warned that by decreasing the step size the CPU time increases.

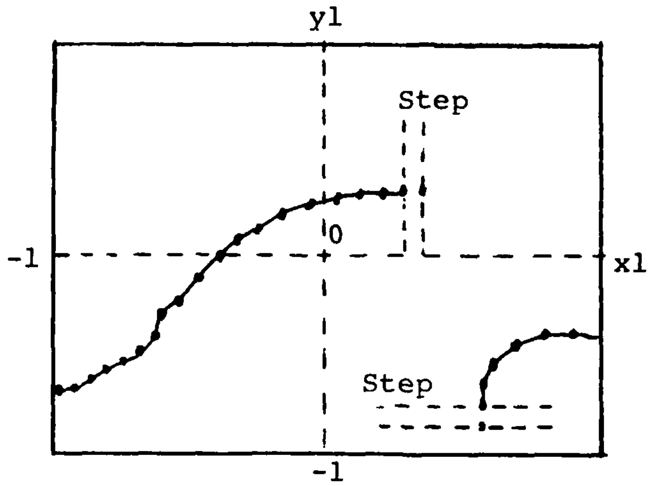


Figure 4.3.12. The STEP command allows the user to set the increment value for x and y steps to be used when plotting contour lines. The same value is used for both x and y direction steps.

4.3.4.25 SUMM (Figure 4.3.13)

The SUMM command gives the user a list of the plotting parameters. It is used to see if the parameters are properly set. Refer to Figure 4.3.13 for an example.

4.3.4.26 SURF (Figure 4.3.6)

The SURF command allows the user to select which surface the contour or relief map will be plotted on. Only one surface per element type is permitted, but each element type may have a different surface. The surfaces are defined by the order in which the connectivities are arranged. The surfaces are numbered one through six as shown in Figure 4.2.9. The default is surface six.

NOTE: The figure shows element type one, however, the surface of the other element types are defined as if they are degenerate type one elements.

4.3.4.27 TIME

The TIME command allows the user to print the CPU time used since the user logged in. On some systems where it is not possible, other functions such as time

```
LABEL ELEMENTS . . . . . . . . NO
PLOT AND LABEL AXES. . . . . . NO
LABEL. . . . . . . . . . . . . NO
PLOT ALL ELEMENTS. . . . . . . YES
PLOT ENTIRE ELEMENT. . . . . . NO
EXPLODED VIEW. . . . . . . . . NO
POSITIVE ARROW . . . . . . . . NO
PLOT STRUCTURE . . . . . . . .UNDEFORMED
PLOT OPTION. . . . . . . . . .RELIEF
MINIMUM VALUE=    53.429     MAXIMUM VALUE= 19361.131
CLIP PLANE FACTOR. . . . . .       0.010
EYE POSITION:
    X-EYE POSITION . . . . .      25.000
    Y-EYE POSITION . . . . .      50.000
    Z-EYE POSITION . . . . .      10.000
SITE POSITION. . . . . . . .       5.000     0.063     0.250
AXIS VERTICAL. . . . . . . . .Z-AXIS
AXIS OF REFLECTION . . . . . .NONE
PROJECTION TYPE. . . . . . . .PERSPECTIVE
        MAXIMUM X=    10.000     MINIMUM X=     0.000
        MAXIMUM Y=     0.125     MINIMUM Y=     0.000
        MAXIMUM Z=     0.500     MINIMUM Z=     0.000
ZOOM IN ...........NO
 STEP SIZE IS ...........     0.050000
LABEL NODES........NO
?
```

Figure 4.3.13. This figure is an example of the SUMM command.

of day may be substituted. This function is especially useful when the user can be automatically logged out when a certain CPU time limit is exceeded.

4.3.4.28 VERT

The VERT command allows the user to decide which axis will appear vertical on the plot. The default is the z axis.

4.3.4.29 WAIT

The WAIT command puts the program into pause. This is useful when the user must leave the terminal for a period of time and does not wish to be automatically logged out due to lack of action. To resume the program execution, the user simply types GO <CR> (carriage return).

4.3.4.30 ZOOM (Figure 4.2.18)

ZOOM is the second command the user can employ in getting a blow-up of a portion of a structure. The structure must first be plotted with the view desired. Then the user specifies a virtual window which encloses that part of the plot on the screen the user desires to view more closely.

This is done using the cursor (two fine crossed lines which appear on the screen once the ZOOM command is implemented). The user adjusts the cursor to the location of the lower left-hand corner of the window he wishes to create using the cursor controls. He then enters any alphanumeric character from the terminal and depresses the "RETURN" key if the terminal is configured to require a carriage return. He repeats this procedure to define the upper right-hand corner of the window he wishes to create. The user may now plot the 'windowed' area at full size on the screen or plotter.

To ZOOM on an HP7221 bed plotter the user must wait until the 'ENTER' light on the plotter control panel begins to flash; he must then move the pen to the lower left corner of the zoom area with the pen controllers (buttons with arrows on them). To enter the coordinates of the lower left corner the user must press the 'ENTER' button. This enters one x, y coordinate pair. The user must then move the pen to the upper right corner of the area to be expanded with the pen controllers and again press the 'ENTER' button. The program will take these two (x,y) coordinate pairs and create a 'window' onto which the zoomed area will be plotted. The user may now plot the structure.

To get a different view of the same area, the user must repeat the entire process. It should be noted that the final image is out of scale (the problem is similar to the one of the virtual plane being mapped into the screen, as described in SCALE). Refer to the CUBE command for an alternative method of enlarging a specific area of a model. It is important to make sure your terminal or plotter has digitizing capability prior to executing this command.

SECTION 5

REFERENCES

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2. a) Control Data Corporation (CDC), CDC NOS/BE Version 1 Batch User's Guide, (60494000) Revision B, CDC Publications and Graphics Division, St. Paul, MN, November 1979.

   b) Control Data Corporation (CDC), CDC NOS/BE Version 1 Reference Manual, (60493800) Revision J, CDC Publications and Graphics Division, St. Paul, MN, May 1980.

   c) Control Data Corporation (CDC), CDC Intercom Version 4 Interactive Guide for User's of FORTRAN Extended (60495000) Revision B, CDC Publications and Graphics Division, St. Paul, MN, October 1978.

   d) Control Data Corporation (CDC), CDC FORTRAN Extended Version 4 Reference Manual, (60497800) Revision E, CDC Publications and Graphics Division, St. Paul, MN, July 1979.

   e) Control Data Corporation (CDC), CDC Intercom Version 4 Reference Manual (60494600) Revision G, CDC Publications and Graphics Division, St. Paul, MN, February 1980.

3. Bogner, F. K., "Structural Flight Loads Simulation Capability, Volume I - Final Report," AFWAL-TR-80-3118, Flight Dynamics Laboratory, Air Force Wright Aeronautical Laboratories, Wright-Patterson Air Force Base, Dayton, Ohio, November 1980.

4. Brockman, R. A., M. E. Wright, M. P. Bouchard, M. J. Hecht, "Structural Analysis Postprocessing Utilities," UDR-TR-80-110, University of Dayton, November 1980.

GLOSSARY

GLOSSARY OF REPORT TERMS

aft — The trailing edge of the wing. This edge is closer to the tail of the plane than the leading edge which is closer to the nose of the plane. Section References 2.8.

analysis — The process of conducting an investigation of structural flight loading simulation of a finite element model. The MAGNA computer program is utilized to perform a flight loads simulation analysis of the wing specimens. Section References 1.1, 1.3, 3.1.

ATTACH — NOS/BE command to gain the interactive computer user access to a data file or computer program stored on auxiliary storage on the CDC 6600 computer. Refer to the NOS/BE INTERCOM manual (Reference 2).

AXES — Command in PLOTBOB plotting program. This allows x-, y-, z axes to be drawn with the structure.

axonometric — A method of representing three-dimensional images on a two-dimensional surface (or screen). The orthogonal projection in the plotting programs utilizes the axonometric method where lines are drawn from a figure in space perpendicular to the surface onto which they are to be displayed. Refer to PROJ (CONTOUR and PLOTBOB) commands in Chapter 4. Section references 4.2.3.12, 4.3.4.20.

bar element — Rib and spar caps and posts are represented with one-dimensional bar elements also called beam elements, truss elements, or MAGNA type 4 elements. These elements are defined with two nodes and a thickness. Section References 2.3.

basic model — The basic model will be generated by WINGEN utilizing the input data prior to damage, modifications, refinements or conversion to shell elements. The basic model uses type 3 and 4 elements (plate and bar) and is composed of ribs, spars, skins, rib and spar caps and posts. Section References 1.1, 2.3.

BATCH mode — The CDC6600 computer allows two methods for user interaction: a) BATCH mode provides the user with the full computing resources of the system but the user cannot control any aspects of what the computer does except by input data cards. All cards are assembled and read into the computer via a card reader or a "card-image" file is created interactively and the BATCH command is utilized to send the information to the computer to perform a task. b) Interactive user of the CDC system may be accomplished through INTERCOM, a facility that allows the user to share a selected portion of the CDC operating system to accomplish a range of tasks while exerting immediate control over the processes. Interactive use of the CDC requires an interactive computer terminal while batch use requires a card reader or interactive computer terminal. Section References 1.2, 2.2, 2.5, 2.8.

baud rate — Computers may send and receive data over telephone wires or "dedicated" wires at various rates depending on the equipment available. The baud rate is a designation of bits of information transmitted every second between the computer and a terminal or other device. The most common speeds today are rates of 300 and 1200 baud. The CDC generally works in CPS units which are characters transmitted per second. See CPS for further information. Section References 2.4, 4.2.1, 4.3.1.

beam element — See bar element.

binary program — Once a computer program has been written and tested, it can be advantageous to store it in a binary program form as opposed to a source program form. The source program is a legible format of the higher level commands. After the program has been compiled and linked, which converts the programming language statements to machine language and adds to the program all the additional modules required from program libraries the user will have a binary program file. This file, while generally larger than a program source file is easier to execute because no compilation is needed. Large programs that require segmented loading are generally handled this way. Section References 2.4.

boundary conditions — Finite element analysis requires that structures which are modelled adhere to certain conditions so the analysis will be accurate. One condition is that the structure must be fixed at some point or there will be no distribution of a load over the structure. A second condition is that elements must be compatible such that the boundary of any one element does not contain more than one other element without special constraints being specified. Third a model should not have any nodes defined which are not used in element connectivities unless the node is constrained. Section References 2.11.1.

card file — Batch mode utilization of the CDC may be accomplished through the use of card decks which are submitted to the CDC control room or read into remote card readers. A card deck or file will have all the necessary job control information to tell the computer what to do with it. The user has no means of interfering with the execution of a batch job. Section References 1.2, 2.2.

card-image file — Users of the CDC may create a card-image file of a card file and store it on auxiliary disk storage in the computer. Once stored on the computer a simple ATTACH command will retrieve the file and make all the data or program source available to the requestor. Consult the NOS/BE operating manuals (Reference 2). Section References 1.2, 2.2.

CATALOG — This NOS/BE command when used with the REQUEST command allows the user to make a file "permanent" on the CDC for future access through ATTACH. A CATALOG'ed file may be removed with a PURGE command. Consult the NOS/BE operating manuals (Reference 2).

CENTER — A preprocessor (WINGEN) control card to reset the center of the loaded plane. Consult section 2.8.12.

centroid — The geometric center of a two- or three-dimensional structure. The centroid is used in determining if an element should be included in the element list by investigating whether the centroid of an element lies within the region to be deleted by damage or modification directives. Section References 4.2.3.16, 4.3.4.9.

characters per second CPS — The transmission rate over phone lines or "hard-wired" terminals is usually given in characters per second (CPS). For most instances the CPS rate of interest will be 30 or 120 which relate with 300 baud and 1200 baud respectively. These rates are utilized as dummy arguments for initializing the plotting software. Section References 2.10, 4.2.2, 4.3.3.

chord	A chord bay is the space encompassed by two spars. A chord bay is numbered by counting from leading edge to trailing edge along the root chord (or rib). The chord bay extends from the root chord to the wing tip. Section Reference 2.8.
chord dimension	The chord dimension refers to the root chord length in the x-axis direction. Section Reference 2.8.3, 2.8.4.
chordwise	The chordwise direction is always from leading edge to trailing edge. Section Reference 2.8.
chordwise depth station	A chordwise depth station is a point along any rib where the wing depth changes with or without a concurrent nodal station defined for rib and spar intersection. Section References 2.8.3, 2.8.4.
chordwise moment	WINGEN will apply a chordwise moment load in the positive x direction to the upper skin nodes and in the negative x direction to the lower skin nodes. Section References 2.8.12, 2.11.
chordwise nodal line	Any change in the wing depth will be defined by a nodal station and all intersections of ribs and spars will be defined as a nodal station. All the nodal stations along a rib collectively define a chordwise nodal line. Section References 2.8.3, 2.8.4.
chordwise shear	WINGEN will apply a chordwise shear load in a positive x direction. Section References 2.8.12, 2.11.
chordwise station	At every point in a model along a rib where the wing depth changes or a spar and rib intersect there is defined a chordwise station at which a node is defined (hence a chordwise nodal station). Section References 2.8.3, 2.8.4.
CLIP	A command for the plotting programs to allow the user to cut away part of the structure for better viewing.
clip plane	A two-dimensional plane defined in a three-dimensional space. All elements and nodes between the clip plane and the viewing position (EYE) will not be displayed, e.g., they will be "clipped" away. Section References 4.2.3.2, 4.3.4.2.

CONL	A CONTOUR program command which allows the user to label the contours of a contour plot. A listing of the contour line values will also be given if the LABE command is optioned.
CONTOUR	One of two plotting programs for the graphical display of finite element model. CONTOUR is specially defined for the display of models to illustrate stress, strain or displacements in the form of contours drawn on the models. Section References 1.4, 4.3.
control directives	The preprocessor program WINGEN requires several pieces of information to allow it to properly handle the model generation. This information is requested at the beginning of the program and is denoted as program control directives. Section References 2.5, 4.3.3.
coordinate origin	All finite element models are generated as a combination of three coordinate points in space. The points or nodes are defined relative to some arbitrary coordinate origin. For the model generation in the preprocessor program the coordinate origin is suggested to be at the intersection of the root chord and the leading edge. Section Reference 2.8.
coordinate transformation	To assist the user in visualizing a correct model it is sometimes necessary to alter the coordinate origin. This is accomplished as coordinate transformation where all coordinates will be shifted according to the user's wishes resulting in the model being oriented in space differently but the model itself will remain the same. Section References 2.8.3, 4.2.3.20, 4.3.4.23.
CORE	A CONTOUR plotting program command which allows the user to select for contour or relief plotting of a structure.
CUBE	A plotting program command which allows the user to create a cube around a model or section of a model. All elements that lie outside the viewing cube will be eliminated.
cursor	A cursor is a positioner for locating points on a viewing screen or data tablet. It consists of fine cross-lines or cross-hairs to aid the user in locating points very exactly; cursor controlers, if the cursor is generated on a screen or other similar device; and a mechanism

to transmit the data point selected, a key board character or special button. Section References 4.2.3.22, 4.3.4.30.

cycle — The CDC computing system allows up to five permanent files to be stored with the same name for each problem number/ID number. Each file is given a cycle number indicating when it was cataloged relative to all other files with that name. The cycle numbers increase from 1 to 999. Section Reference 2.6.

DAMAGE — A preprocessor control card for inflicting damage to a wing model. Section Reference 2.8.11.

damage — A modal may have several types of damage inflicted to it when the model is being created. These damages are essentially removal of elements to simulate structural damage that may be sustained by aircraft in combat situations. Section Reference 2.8.11.

data file — Most computer programs require the user to input certain pieces of information which are then processed and the desired output is returned to the user. In most cases this input information will be typed into the computer either through cards or by an interactive terminal and stored as a group of information within the computer. Such a group of information is known as an input data file. Once a program has finished processing the data input it will generally create an output data file which is a group of information awaiting further processing via another program or review by the engineer. Section References 1.1, 1.2, 1.3, 1.4, 2.2.

DEFAULT — A PLOTBOB plotting program command which resets all plotting parameters to their default values. Same as RESE command for CONTOUR.

DEFO
DEFORM — Plotting program commands which allow the user to plot a deformed or undeformed structure.

DEPTH — A preprocessor program control card which specifies the depth of the wing as being the distance between the upper and lower skins of the wing. Section Reference 2.8.4.

digitize	A user may input to a requesting program certain information concerning an image displayed on a graphics screen. Digitizing is the process of utilizing a cursor controller to position a cursor (or locator) composed of two fine cross-hairs) at a particular position then depressing an appropriate control to send to the program the coordinates of the cursor's position in digital format. The program will do all the necessary conversions to make the digital data into normal cartesian coordinates (x and y values). Section References 4.2.3.22, 4.3.4.30.
displacement of structure	When a structure undergoes analysis due to the application of a load or loads then certain structural changes or deformations are most likely to occur. The displacement of a structure refers to the distance a structure or parts of a structure are moved from the initial position when the load is applied. Displacement or deformed plots will illustrate the deformation of the loaded structure. Section References 3.3, 3.4, 4.2.3.5, 4.3.4.6.
DRAW	A PLOTBOB plotting program command which causes the program to draw the structure utilizing the options selected by the user.
edge location edge surface	Finite elements have surfaces and edges if they have more than one dimension. An edge location or edge surface is one aspect of a finite element. Section References 4.2.3.7, 4.3.4.26.
effective area	Generally, an effective area is that region of a structure or model over which a localized event will have an influence. An effective nodal area is that region over which a load, applied to the node, will be distributed with the greatest effect. Section Reference 2.11.1.
elastic material elastic-plastic material	Structures are composed of materials which may behave differently under different circumstances. Elasticity and plasticity denote two different mechanisms by which materials will respond under differing analytical conditions. Elastic behavior is typical of structures undergoing linear analysis (small displacements) while elastic-plastic behavior is representative of material undergoing nonlinear analysis (large displacements). Section Reference 2.9.

element	A structure may be represented by a mathematical model known as a finite element structure or model. This fem is composed of elements which are linked together via common nodes to accurately represent the model. An element is composed of two or more nodes that define a one, two or three-dimensional space which becomes one building block for a model. A user defines as many of these building blocks as necessary to accurately piece together a representative model of the structure to be analyzed. Section References 1.1, 2.5.
element types	All finite element models are designed for a particular analysis program. The preprocessor WINGEN was designed to utilize three element types: beam (or truss), plate (or membrane) and shell for analysis by MAGNA. Each element type is defined in Reference 2. Section Reference 2.5.
ELEMENTS	A PLOTBOB plotting program command which allows the user to plot selected elements and/or element types. Same as LELE command for CONTOUR.
element connectivities	The same as node connectivities.
ENTE	A CONTOUR plotting program command that allows the user to plot an entire element or only one surface.
EXIT	A contour plotting program command to stop the program execution.
EXPL	A CONTOUR plotting program command to provide the user with an exploded view of the finite elements of a model. Each element is isolated from all the surrounding elements.
EYE EYEP	A plotting program command that allows the user to alter the angle at which the structure being plotted is displayed. Changing the eye position is analgous to holding a model airplane in one's hand and rotating it or moving it closer or farther away.
failure	The analysis of a structure is generally concerned with whether or not the structure can support the test load. If it cannot then structural failure results when some part of

the structure no longer carries the load. Parts of structures may fail without failure of the entire structure.

fem	Abbreviation for finite element model.
finite element	A finite element is a mathematical concept of linking together points in space to represent a physical object. A number of finite elements connected together define a whole structure. Section References 1.1, 2.5.
finite element analysis	The analysis by computer simulation of a finite element model to determine response of system to some type of loading. Section Reference 1.1.
finite element model	A structure represented by a group of three-dimensional coordinates in space which are connected together to form finite elements. These finite elements represent the structure. Section References 1.1, 2.5.
finite element program	A program that conducts a finite element analysis. Section References 1.1, 1.3, 3.1.
FIXTURE	A preprocessor option for applying the loads of an aircraft wing section so that it is distributed as a function of the nodal effective area consisting of wing skins and spars of the clamped load end. Section References 2.8.12, 2.11.
fore	The tip or nose of the airplane is always the fore (forward) part of the structure. The fore part of a wing is that edge which lies closest to the nose of the aircraft. Section References 2.8.
FORMAT	A FORTRAN programming language specification mechanism for inputting data into a program. Consult a FORTRAN language manual for further details. Section Reference 2.8.
geometric nonlinearities	Specifies that an analysis will presumably go beyond the linear response range for the structure being analyzed. Different mathematical techniques are required for nonlinear response of a structure under analysis. Section Reference 2.9.

geometry plot	A plot or graphic picture illustrating the basic components of a structure which has been represented by a finite element model. Section References 2.10, 4.1.
HELP	A plotting program command which gives the user a list of valid program commands.
HPPLOT21	A library of FORTRAN and COMPASS subroutines which enable the pre- and post-processors to plot structures on a Hewlett-Packard HP7221 bed plotter. Section References 2.4, 4.2.1, 4.3.1.
inboard	From any reference point, inboard will refer to a direction which points to the centerline of the fuselage of an aircraft. Section Reference 2.8.
integration points	An analysis must be performed as a function of several specific points of reference in a finite element model. MAGNA will select a minimum number of integration points within an element to compute the various stresses, strains and displacements the structure will undergo during analysis. Section Reference 3.3.
interactive mode	The CDC computing system has facilities for both Batch (remote job processing) and INTERCOM (interactive job processing). Interactive mode allows the user to get an immediate response to inquires or commands at an appropriate terminal from the computer system. Section References 1.2, 2.1, 2.2, 2.5, 2.6. Also see BATCH.
LABE	A CONTOUR plotting program command to provide the user with a title block and contour label values if requested.
LABELS	A PLOTBOB plotting program command to allow the user the option of labelling the nodes and/or elements of a model. Same as LELE command for CONTOUR.
LAXS	A CONTOUR plotting program command which permits the drawing and labelling of a set of axes for a model. Same as AXES command for PLOTBOB.
leading edge	The edge of the wing which lies closest to the nose of the aircraft is the fore edge or leading edge of the aircraft wing. Section References 2.5, 2.8.

LELE	A CONTOUR plotting program command which allows the user the option of labelling the nodes and/or elements. Same as LABELS command for PLOTBOB.
library subroutines	A group of auxiliary subroutines which have a common purpose for a number of unique programs will generally be placed in a special file and utilized only when required by the programs. This file is known as a library and will be searched by the system linker for subroutines not otherwise provided by the programmer. Section References 2.4, 4.2.1, 4.3.1.
linear analysis	Under very slight loading, a structure behaves linearly - that is, the strains are linear functions of the displacements, and the stress-strain law is of linear elastic type. A linear analysis is performed under these assumptions, and, therefore, represents a "straight line" approximation to the initial load-deflection response. Section Reference 2.9.
linear constraints	Restrictions on how nodes behave under loading conditions may be imposed by limiting node displacements to be a linear combination of displacements of surrounding nodes. Section Reference 2.11.2.
literal	Any group of letters and/or numbers to be used exactly as they appear. Section Reference 2.8.
load	A load is any force applied to the structure either directly or indirectly. Section Reference 2.8.12, 2.11.
LOAD	A preprocessor control card for designating the amount of loading (breakdown of forces) to be applied to the structure. Section Reference 2.8.12.
load conditions	Several items must be determined in order to distribute the loads on the finite element model properly such as: the center of the load plane, the magnitude and directions of the loads, the load axis of the wing, etc. These all comprise the load conditions. Section Reference 2.11.

load deck	The main function of the preprocessor is the creation of a file of finite elements and loading specifications for input to the MAGNA finite element program. Such a file is called a load deck. Section References 1.1, 1.2, 1.3, 2.9, 3.2.
load step (increment)	The MAGNA analysis program allows the user to specify the size of a step in load for each iteration of a solution as a number of total iterations to be used in performing the solution. A load step is that fraction of the load to be applied during each solution increment. Section Reference 2.9.
local file	The CDC has three file designations: permanent, temporary and local. A local file can be either permanent or temporary but exists only for the duration of an INTERCOM terminal session or BATCH job execution. If the local file was permanent it is returned to its storage after the user is finished; if it was temporary, it will be disposed of. No files are ever automatically made permanent by the CDC. Section References 2.4, 2.6, 2.7, 2.8, 2.9.
LOGIN	A CDC command requesting the computer to acknowledge your desire to utilize the INTERCOM interactive features from a computer terminal. Section References 2.4, 4.2.1, 4.3.1.
MAGNA	A computer program for the Materially And Geometrically Nonlinear Analysis of finite element models. See Reference 1. Section References 1.3, 3.1.
MAGNA load deck	A production of the preprocessor, the load deck contains all the information to cause a BATCH execution of MAGNA. Section References 1.2, 3.2.
material nonlinearities	Same concept as for geometric nonlinearities except that material forces are the subject instead of geometric displacement. Section Reference 2.9.
material property code	A preprocessor code which indicates what type of material a particular part of a wing structure was made of. Aluminum and

	steel property codes (1 and 2) are generally used. Section References 2.8.5, 2.8.6, 2.8.7, 2.8.9.
MC	Chordwise moment loading applied to wing. Section References 2.8.12, 2.11.
membrane elements	Two-dimensional elements which include only in-plane stress and strain effects. Membrane elements utilized in this program are of two subtypes: shear panel (subtype 3) and plane stress (subtype 1). They are also referred to as shear panel (for ribs and spars) and plane stress (for skins) elements. Section Reference 2.5.
mesh	Refers to the size of the finite element with respect to the structure being represented. A coarse mesh is one where very few finite elements will define a section or entire structure. A fine mesh may contain as many as two dozen smaller elements where only one coarse element was defined previously. Section References 1.1.
mesh refinement	A finite element mesh may be made finer by specifying a refinement. Generally a two or three fold increase in the number of elements will be desired in a refinement but more are possible as well as the feasibility of only increasing the density (reducing the size) of elements in selected regions of the model. Section References 1.1, 2.8.10.
model	A group of finite elements which define a physical structure. Section References 1.1, 2.5.
model coordinate region	The point at which all nodal coordinates are referenced from. Generally, the origin is selected to be at the intersection of the leading edge and root chord of the wing. Section Reference 2.8.
model geometry plot	A graphic illustration of a finite element model. Section References 2.10, 4.1.
MODIFY	A preprocessor control card specifying that certain areas of a generated model should have certain structural components omitted. Section References 2.8.8.

MPOST	An output data file generated by MAGNA as a result of the structural analysis. This file is used by CONTOUR and PLOTBOB for postprocessing of the data into various kinds of plots. Section References 1.3, 1.4.
MS	Spanwise moment load to wing. Section References 2.8.12, 2.11.
MT	Torque moment load applied to wing. Section References 2.8.12, 2.11.
NEST	A CONTOUR plotting program command permitting the user to utilize the data of another structure on a multiple-structure data file.
NEW	A PLOTBOB plotting program command that permits the user to utilize the data of another structure on a multiple-structure data file.
NEWD	A CONTOUR plotting program command that allows the user to plot a different solution increment for a structure with more than one load increment on the file.
node	Three-dimensional coordinates located in reference to an origin (the model coordinate origin) which are associated together to form building blocks of regular geometric shapes known as finite elements. These finite elements are defined so they accurately represent a structure to be analyzed. Section Reference 1.1.
NODE	A CONTOUR plotting program command to allow the user the option of labelling the nodes of a structure plot.
node connectivities	Nodes defined as three coordinate points in space relative to a model coordinate origin are associated in particular sequences and numbers to form geometric shapes called elements. These elements may be one, two or three-dimensional in nature. By incorporating nodes into several elements, element connectivities are formed associating one element with another. Enough associated finite elements are defined to represent a physical structure. The association of nodes to form elements is called nodal connectivity. Section References 2.8.5, 3.2.

nonlinear analysis	A nonlinear structural analysis in general takes into consideration the nonlinear relations between strain and displacements (which is necessary when the displacements are finite) and between stress and strain (due, for example, to plastic deformation). Since the governing equations are nonlinear, a solution is typically obtained in an iterative fashion at any level of loading.
outboard	From any reference point the outboard direction is from that point away from the center line of the fuselage of the aircraft. Generally, outboard refers to a direction from the wing root to the wing tip. Section Reference 2.8.
permanent file	The CDC has three file designations: permanent, local and temporary. A permanent file is one the user has made a request to be permanent and then cataloged. A temporary file will be created only for the duration of an INTERCOM session or a BATCH job execution and is a local file. Any permanent files used during an INTERCOM or BATCH session will be made a local file until the session is over and returned to its storage location. Section Reference 2.5, 2.6, 4.2.1, 4.3.1.
plane stress element	Same as membrane element subtype 1. Section Reference 2.5.
plate element	Two-dimensional finite elements in which both inplane and transverse bending effects are taken into account. Out-of-plane bending deformations may complicate the finite element by necessitating the use of rotations or similar variables as nodal degrees of freedom.
planform	A planform description indicates the general pattern of how the wing is situated with respect to the fuselage of the aircraft: either swept fully, partially swept or rectangular (no sweep). Section Reference 2.8.3.
PLANFORM	A preprocessor card which specifies the planform code. Section Reference 2.8.3.
PLOT	A CONTOUR plotting program command that provides the user with a graphic presentation of the finite element model currently being postprocessed utilizing the plotting options selected prior to the command.

PLOTBOB	A pre- and post-processing graphics program which will plot a MAGNA load deck file or a MAGNA MPOST file (WINGMPOST). Section References 1.4, 4.2.
PLOT3D	A library of subroutines designed to allow the 3-D plotting of structures on a 2-D surface. Section References 2.4, 4.2.1, 4.3.1.
POSA	A CONTOUR plotting program command allowing the user to have an arrow plotted with the structure indicating the positive direction of what force or displacement option has been selected.
postprocessor	A program which accepts data from a finite element analysis program and further interprets or reduces that data for easier interpretation, generally, in the form of plots. Section References 1.1, 1.4, 4.1.
posts	Addition of vertical one-dimensional elements between the upper and lower skins, known as posts, are to give the model structural integrity for analysis purposes. These are essentially theoretical constructs to allow the model to be analyzed properly. Section References 2.5, 2.8, 2.8.9.
POSTS	A preprocessor control card specifying the generating options for the posts. Section Reference 2.8.9.
preprocessor	A program which utilizes simplified input to perform the tedious chores of generating a detailed finite element model ready for analysis by a finite element program. Section References 1.2, 1.2, 2.1.
preprocessor data file	The preprocessor WINGEN has an optional input data file for wing model generation which contains abbreviated wing descriptions. This information will be used to generate an optional output data file called the load deck which is a detailed listing of nodes, elements and all other information for a finite element model. Section Reference 1.1.
profile class	The preprocessor requires the user to input a profile class for the wing model to be generated. This profile is a combination of the planform code and the chordwise and spanwise depth distributions. Section Reference 2.8.2.
PROFILE	A preprocessor control card which defines the profile class. Section Reference 2.8.2.

PROJ PROJECTION	A plotting program command which allows the user to select a perspective or an orthogonal projection of an image onto the screen.
projection plane	An image is defined in a three-dimensional space but must be represented on a two-dimensional surface. The projection plane is defined as the surface on which all points in the 3-D model are imposed or mapped to yield a 2-D representation of the model. Section References 4.2.3.12, 4.3.4.20.
PURGE	A CDC BATCH or INTERCOM command used to eliminate unneeded permanent files. Consult Reference 2.
refined model	A model where the original mesh generated by connecting the basic nodes to form elements yields a normal and usually a coarse mesh model. A refined model is one where the mesh has been made finer by the addition of more nodes and the elements rearranged so they are smaller. Section References 1.1, 2.8.10.
REFINE	A plotting program control card which specifies which areas of a model require a finer mesh generation. Section Reference 2.8.10.
REFL REFLECT	A plotting program command which enables the user to draw a plot of the model plus its reflection about an axis. This is helpful if half of a symmetrical structure is modeled.
reflection of model	A model may have its mirror image plotted along with the basic model. This is reflection, which must be done about one of the axis. Section References 4.2.3.14, 4.3.4.21.
REQUEST	A CDC BATCH and INTERACTIVE command which allows a file to be initialized so that it may be made permanent by a CATALOG command. Further information may be found in Reference 2.
RESE	A CONTOUR plotting program command which resets all options for plotting to their default values. Similar to DEFAULT command for PLOTBOB.
rib	A structural component of a wing which runs from the leading edge to the trailing edge of a wing. Several ribs will be present in any given wing. Section References 1.2, 2.8, 2.8.6.
RIB	A preprocessor control card designating required information for rib generation. Section Reference 2.8.6.

rib cap — A structural component of ribs is a stringer that is placed in conjunction with the rib to lend structural support and allow attachment of the skins at the rib junctions. Section References 1.1, 2.8, 2.8.6.

root chord — The root of a wing is that part of the wing model which lies closest to the centerline of the aircraft being modeled. The root chord is the first nodal station defined for the wing. The root chordwise chord runs from leading edge to trailing edge in an almost parallel line with the centerline of the aircraft. Section Reference 2.8.

ROTATE — A PLOTBOB plotting program command which allows the user to rotate the model about an axis.

rotation of model — A rotated model is a model that has simply been turned so that a different part of the model faces the viewer. No other changes are incorporated. Section References 4.2.3.14, 4.3.4.28.

SCALE — A PLOTBOB plotting program command that allows the user to alter the scale of a plot, generally, to make the horizontal and vertical distances proportional.

semi-interactive mode — The WINGEN preprocessor has three operating modes: batch; interactive and semi-interactive. The semi-interactive mode utilizes the batch mode data file (Section 2.8) but executes under user interaction for plot generation and monitoring of model generation characteristics. Section References 1.2, 2.2, 2.5, 2.7.

shear panel elements — Same as membrane elements subtype 3. Section Reference 2.5.

shell element — A finite elememt type with three-dimensional characteristics requiring eight nodes to define. Section References 2.5, 2.8.10.

shell element model — A finite element model utilizing shell elements. In this situation, shell elements compose the top and bottom skins. Section Reference 2.5.

SHRINK — A PLOTBOB plotting program command which allows the user to shrink all elements about their centroids yielding an "exploded" view of the model.

SITE	A CONTOUR plotting program command which allows the user to select a different point within the model to be the viewing "center" of the model.
skin	The material covering the frame of the aircraft; most notably, the material covering the wing frame composed of ribs, spars and stringers. Section Reference 2.8.5.
span bay	The chordwise section between two adjacent ribs forms a span bay. Section Reference 2.8.
span dimension	The perpendicular distance from the root chord to the intersection with a line passing through the wing tip chord (or rib). Section References 2.8, 2.8.3, 2.8.4.
spanwise	The direction from the root chord to the wing tip (outboard). Section Reference 2.8.
spanwise depth station	A point along a spar between the root chord and wing tip where there is a change in the depth between the upper and lower wing skins. Section Reference 2.8.3, 2.8.4.
spanwise nodal station	A point along a spar between the root chord and wing tip, inclusive, where a node has been defined. Section Reference 2.8.3, 2.8.4.
spanwise moment	A torque force which acts about the root chord of the wing with the wing tip - MS. Section Reference 2.11.1.
spanwise shear	A vertical displacing force upon the wing, positive in the positive z direction - VS. Section Reference 2.11.1.
spar	A wing structural component which runs from the center line of the fuselage to the wing tip. Section References 1.1, 2.8, 2.8.7.
SPAR	A preprocessor control card specifying required information for spar generation in the model. Section Reference 2.8.7.
spar cap	A wing structural component assocated with a spar. The cap runs adjacent to the spar, lends structural stability and allows a surface for wing skin attachment. Section References 1.1, 2.8, 2.8.7.

STEP	A CONTOUR plotting program command which allows the user to alter the computed step size while calculating contours.
stiffeners	In wing design it sometimes is desirable to add lightweight structural supports to the skins to keep them from "buckling". Stiffeners are strips of metal that run along the skin generally between rib and spar webs to lend additional support to the wing skin. Section Reference 1.1.
stress/strain codes	MAGNA analysis of a fem will yield results which are broken down into various classes of stresses and strains such as xx, xy, yz, etc., in terms of a local coordinate system for the type 3 element types. The CONTOUR plotting program will request the user to select one type of stress or strain from a list of codes available. Section Reference 4.3.3.
structure	Any material constructed in such a way as to carry a load. Section Reference 1.1.
structural analysis technique	A method by which a structure is represented by a system of finite elements and analyzed by a finite element program. Section Reference 1.1.
SUBT	A CONTOUR plotting program command which allows the user to specify a subtitle to be placed on a plot if the LABE option is also selected.
SUMM SUMMARY	A plotting programs command which provides the user with a list of the plotting options currently selected.
SURF	A CONTOUR plotting program command which allows the user to specify which surface of an element type or types to plot.
TAPE4	A preprocessor program local file containing input data for the generation of a wing finite element model. Section References 2.7, 2.8.
TAPE5	A PLOTBOB plotting program local file containing a data file of which plots will be drawn. Section Reference 4.2.1.
TAPE6	A preprocessor program local output file containing the data necessary for the regeneration of a model by WINGEN. This is

	created by an interactive terminal session and is made a permanent file by WINGEN prior to program execution provided cycle space is available. Section Reference 2.6.
TAPE11	A preprocessor program local output file containing the MAGNA analysis load deck. The user must catalog this file if he wishes to keep it. Section Reference 2.9.
TAPE99	A CONTOUR plotting program local input file containing an MPOST data file for postprocessing into plots. Section Reference 4.3.1.
TEKLIB	A library of subroutines utilized by the pre- and postprocessors for creating plots on a Tektronix graphics device. Section References 2.4, 4.2.1, 4.3.1.
test load	WINGEN provides the user with two means of specifying a load upon a wing model for analysis by MAGNA. The test load applies the loads over the wing tip based on an associated end wing skin area for each node. Section References 2.8.12, 2.11.1.
TIME	A plotting programs command that provides the user with the total CPU time that has elapsed since the start of the program execution.
title	The preprocessor requests a problem title to be placed on the data files for identification purposes. Section Reference 2.8.1.
torque	One of the loading forces that can be applied to the wing. Section References 2.8.12, 2.11.
TRANSLATE	A PLOTBOB plotting program command which permits the user to move the model from the origin a designated distance in any direction.
translation of model	The process of altering the model coordinate origin. Section References 4.2.3.20, 4.3.4.23.
truss element	A bar element.
USRDATAFILE	WINGEN will provide the user with a permanent file named USRDATAFILE at the conclusion of an interactive program execution. This permanent file will be present as a local file TAPE7 until the user executes a LOGOUT. Section Reference 2.6.

VERT VERTICAL	A plotting programs command which allows the user to alter which axis is to be vertical for plots.
viewing box	The plotting programs display of 3-D image on a 2-D surface utilizing a range of coordinate values (from min x to max x and min y to max y) to create an imaginary box around the structure. Only those elements that lie within the box are plotted. Section References 4.2.3.3, 4.3.4.5.
virtual plane	Prior to plotting a structure it will be mapped from a three-dimensional set of coordinates to a two-dimensional plane surface which is then drawn on the screen. The object may be mapped using one of several projection options but the result is always a two-dimensional virtual plane containing the final image. Section References 4.2.3.12, 4.3.4.20.
WAIT	A CONTOUR plotting program command that places the program in a pause state until the user types 'GO' or the computer idle times (time of last terminal input/output signal) is exceeded. Currently, idle time before a forced logout is five minutes.
window	Once an object has been mapped onto a virtual plane (three-dimensional structure converted to two-dimensional structure) it is ready to be displayed. A window is established at the graphics device which allows the user to decide how much of the image on the virtual plane will be displayed or more properly what range of x and y coordinates in a two-dimensional system will be actually drawn. Section References 4.2.3.22, 4.3.4.30.
wing depth	The distance (vertical or z direction, usually) between the upper skin and the lower skin. Section References 2.8.3, 2.8.4.
wing depth distribution	A preprocessor requirement for wings with changes in wing depth is that the user specify in a regular pattern how the wing depth changes over the entire wing. Section Reference 2.8.4.
wing planform	Several basic wing types are accommodated for fem generation by the preprocessor including the classes of full swept (leading edge is straight from fuselage to wing tip), partially swept (wing is swept in sections, e.g., the leading edge is not straight), and rectangular

	(The leading edge is perpendicular to the fuselage). When wing sections are being analyzed the whole section as it rests in the test frame must be regarded as a wing where the test frame is the fuselage. Section References 2.8.3.
wing profile	The preprocessor requires the user to specify the combinations of planform and depth distributions over span and chord sections of the wing. These three wing specifications form the wing profile. Section Reference 2.8.2.
wing skin	See skin.
WINGEN	Preprocessor program which inputs simplified wing geometries and generates a complete finite element model file ready for analysis by MAGNA. Section References 1.2, 2.1.
yielding	For stresses greater than a certain level (called the yield stress), permanent deformations of a material may occur, and the relationship between strain and stress becomes nonlinear. The onset of permanent, or "plastic", deformation is called yielding. In two or three dimensions, yielding is determined in most metals by the von Mises criterion, which equates the distortional energy at a point to the corresponding energy in a uniaxial specimen at the point of first yielding.
ZOOM	A plotting program command which allows the user to plot a closer view of a section of a model.

APPENDIX

```
ASD COMPUTER CENTER INTERCOM 5.0
SYSTEM  CSA
DATE  08/27/80      TIME  21.18.30.

PLEASE LOGIN
LOGIN
ENTER PROBLEM NUMBER-D770043
[redacted] ENTER PASSWORD-
ENTER 3-DIGIT TERMINAL ID-098


08/27/80   LOGGED IN AT  21.18.55.
           WITH USER-ID U8
           EQUIP/PORT 16/023
COMMAND- ATTACH,F,WINGEN,ID=D800106
 PF CYCLE NO. = 001
COMMAND- F.


   INTERACTIVE RUN?(Y,N)..................: Y
   CREATE A LOADECK?(Y,N).................: Y
   GENERATE A GRAPH?(Y,N).................: Y
   DO YOU WANT A LISTING OF NODAL COORDINATES?(Y,N).: N
   DO YOU WANT A LISTING OF ELEMENT CONNECTIVITY?(Y,N): N



   START
```

Appendix A - Preprocessor WINGEN Program Execution

Section A - login procedure for executing an interactive run of WINGEN.

```
LOGIN
ENTER PROBLEM NUMBER-D770043
[redacted] ENTER PASSWORD-
ENTER 3-DIGIT TERMINAL ID-098

08/27/80   LOGGED IN AT  21.23.27.
           WITH USER-ID U8
           EQUIP/PORT 16/023
COMMAND- ATTACH,F,WINGEN,ID=D800106
 PF CYCLE NO. = 001
COMMAND- ATTACH,TAPE4,WINGDATAT38
 PF CYCLE NO. = 001
COMMAND- F.

   INTERACTIVE RUN?(Y,N)..................: N
   CREATE A LOADECK?(Y,N).................: Y
   GENERATE A GRAPH?(Y,N).................: Y
   DO YOU WANT A LISTING OF NODAL COORDINATES?(Y,N).: N
   DO YOU WANT A LISTING OF ELEMENT CONNECTIVITY?(Y,N): N

   START
```

Section B - login procedure for executing a semi-interactive run of WINGEN.

```
COMMAND- REWIND,TAPE4
COMMAND- COPYSBF,TAPE4

  REPLICA TEST SPECIMEN
PROFILE P1 C1 S1
PLAN      53.88      74.5
DEPTH
     17.75
SKIN      1     1    .25000     .25000
RIBS      5
    2     1     1      0.00       9.30      53.88       9.30
     .1000     .1500
    2     1     1      0.00      19.60      53.88      19.60
     .1000     .1500
    2     1     1      0.00      31.20      53.88      31.20
     .1000     .1500
    2     1     1      0.00      43.90      53.88      43.90
     .1000     .1500
    2     1     1      0.00      59.60      53.88      59.60
     .1000     .1500
SPARS     4
    2     1     1      0.00       0.00       0.00      74.50
     .1875    2.6250
    2     1     1     17.97       0.00      17.97      74.50
     .1250    1.8750
    2     1     1     35.91       0.00      35.91      74.50
     .1250    1.8750
    2     1     1     53.88       0.00      53.88      74.50
     .1875    2.6250
MODIFY
POSTS    -1
                2    0
    0.0000     .3000
```

Section C - the complete TAPE4 file used by WINGEN in the semi-interactive execution.

```
REFINE   1
THICK         1
DAMAGE   1
SKINL         4    2
LOADS    1
CENTER   0
TEST
       0.0        0.0                  2.E6        0.0        0.0

COMMAND-
```

```
COMMAND- ATTACH,F,WINGEN
 PF CYCLE NO. = 001
COMMAND- ATTACH,TAPE4,USRDATAFILE
 PF CYCLE NO. = 001
COMMAND- F.


   INTERACTIVE RUN?(Y,N)..................: N
   ETC........


STOP

COMMAND- FILES
--LOCAL FILES--
  TAPE8    $INPUT    $OUTPUT   *F        *TAPE4
  TAPE11    TAPE10
COMMAND- REQUEST,A,*PF
COMMAND- REWIND,TAPE11,A
COMMAND- COPYSBF,TAPE11,A
COMMAND- CATALOG,A,MAGNAINPUTT38WING,RP=100
 INITIAL CATALOG
 CT ID=  D770043 PFN=MAGNAINPUTT38WING:
 CT CY= 001  00001792 WORDS.:
COMMAND- BATCH,TAPE11,INPUT

    OR
    ==

COMMAND- BATCH,A,INPUT...(for MAGNA program execution)
```

Section D - Process for executing WINGEN preprocessor program and the cataloging of the load deck file (TAPE11) as a permanent file and a subsequent execution of MAGNA.

```
LOGIN
ENTER PROBLEM NUMBER-D770043
[redacted] ENTER PASSWORD-
ENTER 3-DIGIT TERMINAL ID-098

08/27/80   LOGGED IN AT  21.39.41.
           WITH USER-ID U8
           EQUIP/PORT 16/023
COMMAND- ATTACH,A,T38WINGMAGNAINPUT
 PF CYCLE NO. = 001
COMMAND- BATCH,A,INPUT
```

Appendix B - Analysis (MAGNA) Program Execution

Section A - login procedure for executing a MAGNA analysis run of load deck file.

```
COMMAND- REWIND,A
COMMAND- COPYSBF,A

UD5K,T500,IO600,CM140000,STANY. D770043,BRUNER,KL565,93351-94
SET,R1=MFL.
COPYCR,INPUT,TAPE5.
REQUEST,MPOST,*PF.
ATTACH,P,MAGNAJCL,ID=BROCKMAN.
BEGIN,XMAGNA,P,MAIN,,R1+B.
CATALOG,MPOST,WINGMPOST,RP=600.
        T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
          CASE 6 - THIRD RUN

   1    1    1    1    0    1    1    0    0    0    1
   1    1
    1.0000     0.0000
     .2500      .5000
     .0000      .0000
COORDINATES        70
    1          0.0000     0.0000    -1.9945
    2          0.0000     0.0000     1.9945
    3          6.3900     0.0000    -2.2425
    4          6.3900     0.0000     2.2425
    5         12.8500     0.0000    -2.4440
    6         12.8500     0.0000     2.4440
    7         19.3800     0.0000    -2.5650
    8         19.3800     0.0000     2.5650
    9         25.9900     0.0000    -2.6145
   10         25.9900     0.0000     2.6145
   11         31.5500     0.0000    -2.5940
   12         31.5500     0.0000     2.5940
   13         58.4800     0.0000    -2.1900
   14         58.4800     0.0000     2.1900
```

Section B - first several lines of load deck file used to execute MAGNA analysis.

```
LOGIN
ENTER PROBLEM NUMBER-D770043
[redacted] ENTER PASSWORD-
ENTER 3-DIGIT TERMINAL ID-098

08/27/80   LOGGED IN AT  21.28.39.
           WITH USER-ID U8
           EQUIP/PORT 16/023
COMMAND- ATTACH,F,PLOTTINGPROCEDURES,ID=D800106
 PF CYCLE NO. = 001
COMMAND- ATTACH,TAPE5,WINGMPOST
 PF CYCLE NO. = 003
COMMAND- BEGIN,PLTBOB,F
   ENTER THE CHARACTERS PER SECOND .............:
 PF CYCLE NO. = 999
 PF CYCLE NO. = 999
                   120
```

Appendix C - Postprocessor (PLOTBOB and CONTOUR) Programs Execution

Section A - login procedure for executing PLOTBOB plotting program with a Tektronix graphics terminal at 1200 baud (120 cps) utilizing an MPOST file.

```
COMMAND- REWIND,TAPE5
COMMAND- COPYSBF,TAPE5

               T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
                 CASE 6 - THIRD RUN

    1    1
   1   1   1   1   0   1   1   0   0   0   1   0   0   0   0   0   0   0
   0   0
COOR              70
    1      0.00000+ 00.00000+ 0-.19945+ 1
    2      0.00000+ 00.00000+ 0 .19945+ 1
    3       .63900+ 10.00000+ 0-.22425+ 1
    4       .63900+ 10.00000+ 0 .22425+ 1
    5       .12850+ 20.00000+ 0-.24440+ 1
    6       .12850+ 20.00000+ 0 .24440+ 1
    7       .19380+ 20.00000+ 0-.25650+ 1
    8       .19380+ 20.00000+ 0 .25650+ 1
    9       .25990+ 20.00000+ 0-.26145+ 1
   10       .25990+ 20.00000+ 0 .26145+ 1
   11       .31550+ 20.00000+ 0-.25940+ 1
   12       .31550+ 20.00000+ 0 .25940+ 1
   13       .58480+ 20.00000+ 0-.21900+ 1
   14       .58480+ 20.00000+ 0 .21900+ 1
   15      0.00000+ 0  .29920+ 2-.19945+ 1
   16      0.00000+ 0  .29920+ 2 .19945+ 1
   17       .64386+ 1  .28968+ 2-.22425+ 1
   18       .64386+ 1  .28968+ 2 .22425+ 1
   19       .12918+ 2  .28009+ 2-.24440+ 1
   20       .12918+ 2  .28009+ 2 .24440+ 1
   21       .19445+ 2  .27044+ 2-.25650+ 1
   22       .19445+ 2  .27044+ 2 .25650+ 1
   23       .26030+ 2  .26070+ 2-.26145+ 1
```

Section B - first several lines of the MPOST file being utilized in Section A above.

```
LOGIN
ENTER PROBLEM NUMBER-D770043
[redacted] ENTER PASSWORD-
ENTER 3-DIGIT TERMINAL ID-098

08/28/80   LOGGED IN AT  11.26.19.
           WITH USER-ID U8
           EQUIP/PORT 16/023
COMMAND- ATTACH,F,PLOTTINGPROCEDURES,ID=D800106
 PF CYCLE NO. = 001
COMMAND- ATTACH,TAPE5,T38WINGMAGNAINPUTCASE6,ID=BRUNER
 PF CYCLE NO. = 002
COMMAND- BEGIN,PLTBOB,F,HP
 PF CYCLE NO. = 999
 PF CYCLE NO. = 999
   ENTER THE CHARACTERS PER SECOND .............: 30
```

Section C - login procedure for executing PLOTBOB plotting program with a Hewlett-Packard bed plotter at 300 baud (30 cps) utilizing a load deck (MAGNA input) file.

```
COMMAND- REWIND,TAPE5
COMMAND- COPYSBF,TAPE5

UD5K,T500,IO600,CM140000,STANY. D770043,BRUNER,KL565,93351-94
SET,R1=MFL.
COPYCR,INPUT,TAPE5.
REQUEST,MPOST,*PF.
ATTACH,P,MAGNAJCL,ID=BROCKMAN.
BEGIN,XMAGNA,P,MAIN,,R1+B.
CATALOG,MPOST,WINGMPOST,RP=600.
       T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
         CASE 6 - THIRD RUN

   1   1   1   1   0   1   1   0   0   0   1
   1   1
    1.0000     0.0000
     .2500      .5000
     .0000      .0000
COORDINATES        70
     1         0.0000     0.0000    -1.9945
     2         0.0000     0.0000     1.9945
     3         6.3900     0.0000    -2.2425
     4         6.3900     0.0000     2.2425
     5        12.8500     0.0000    -2.4440
     6        12.8500     0.0000     2.4440
     7        19.3800     0.0000    -2.5650
     8        19.3800     0.0000     2.5650
     9        25.9900     0.0000    -2.6145
    10        25.9900     0.0000     2.6145
    11        31.5500     0.0000    -2.5940
    12        31.5500     0.0000     2.5940
    13        58.4800     0.0000    -2.1900
    14        58.4800     0.0000     2.1900
```

Section D - first several lines of load deck file used for plotting in Section C above.

```
LOGIN
ENTER PROBLEM NUMBER-D770043
[redacted] ENTER PASSWORD-
ENTER 3-DIGIT TERMINAL ID-098

08/27/80   LOGGED IN AT  21.34.07.
           WITH USER-ID U8
           EQUIP/PORT 16/023
COMMAND- ATTACH,F,PLOTTINGPROCEDURES,ID=D800106
 PF CYCLE NO. = 001
COMMAND- ATTACH,TAPE99,WINGMPOST
 PF CYCLE NO. = 003
COMMAND- BEGIN,PLOT,F
ENTER CHARACTORS PER SECOND------
 PF CYCLE NO. = 999
                  120
```

Section E - login procedure for executing CONTOUR plotting program on a Tektronix graphics terminal at 1200 baud (120 cps) utilizing an MPOST file (see Section G below for a sample listing of the MPOST file).

```
LOGIN
ENTER PROBLEM NUMBER-D770043
[redacted] ENTER PASSWORD-
ENTER 3-DIGIT TERMINAL ID-098

08/27/80   LOGGED IN AT  21.36.21.
           WITH USER-ID U8
           EQUIP/PORT 16/023
COMMAND- ATTACH,F,PLOTTINGPROCEDURES,ID=D800106
 PF CYCLE NO. = 001
COMMAND- ATTACH,TAPE99,WINGMPOST
 PF CYCLE NO. = 003
COMMAND- BEGIN,PLOT,F,HP
ENTER CHARACTORS PER SECOND------
 PF CYCLE NO. = 999
                  30
```

Section F - login procedure for executing CONTOUR plotting program on a Hewlett-Packard bed plotter at 300 baud (30 cps) utilizing an MPOST file.

```
COMMAND- REWIND,TAPE99
COMMAND- COPYSBF,TAPE99

         T38 WING / LINEAR ANALYSIS /  MODEL DEVELOPMENT
           CASE 6 - THIRD RUN

  1    1
 1   1   1   1   0   1   1   0   0   0   1   0   0   0   0   0   0   0
 0   0
COOR          70
   1     0.00000+ 00.00000+ 0-.19945+ 1
   2     0.00000+ 00.00000+ 0 .19945+ 1
   3      .63900+ 10.00000+ 0-.22425+ 1
   4      .63900+ 10.00000+ 0 .22425+ 1
   5      .12850+ 20.00000+ 0-.24440+ 1
   6      .12850+ 20.00000+ 0 .24440+ 1
   7      .19380+ 20.00000+ 0-.25650+ 1
   8      .19380+ 20.00000+ 0 .25650+ 1
   9      .25990+ 20.00000+ 0-.26145+ 1
  10      .25990+ 20.00000+ 0 .26145+ 1
  11      .31550+ 20.00000+ 0-.25940+ 1
  12      .31550+ 20.00000+ 0 .25940+ 1
  13      .58480+ 20.00000+ 0-.21900+ 1
  14      .58480+ 20.00000+ 0 .21900+ 1
  15     0.00000+ 0 .29920+ 2-.19945+ 1
  16     0.00000+ 0 .29920+ 2 .19945+ 1
  17      .64386+ 1 .28968+ 2-.22425+ 1
  18      .64386+ 1 .28968+ 2 .22425+ 1
  19      .12918+ 2 .28009+ 2-.24440+ 1
  20      .12918+ 2 .28009+ 2 .24440+ 1
  21      .19445+ 2 .27044+ 2-.25650+ 1
  22      .19445+ 2 .27044+ 2 .25650+ 1
  23      .26030+ 2 .26070+ 2-.26145+ 1
```

Section G - a sample listing of the first part of the MPOST file utilized in Sections E and F above.